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Market milk

CENTRAL FOOD TECHNOLOGICAL RESEARCH I
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MARKET MILK

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BY

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SECOND EDITION, REWRITTEN

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by

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Market milk

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PREFACE TO SECOND EDITION

THE revised edition of *Market Milk* has been prepared in order to keep the book as nearly up-to-date as possible. New methods of handling market milk are constantly being developed, and in order to make the book authoritative and usable it is necessary that these changes be recognized and included in the text. This is especially true as to the handling of market milk in city milk plants, and the chapters relating to milk-plant equipment and operation have been extensively revised.

Minor changes have been made throughout: Chapter XIV has been almost completely rewritten, with much added material, and a separate chapter on country receiving stations has been added. The two chapters on "Milk Plant Operation" in the first edition have been combined into one chapter. Chapter XXIV has been revised so as to include as much recent data on the cost of milk distribution as is obtainable.

The extensive use which was made of the first edition has encouraged the authors to proceed with the revised edition, and it is hoped that the book in this form will prove even more useful to students and others interested in market-milk problems than before.

The authors are indebted to the Department of Agriculture and to manufacturers of milk-plant equipment, through whose courtesy many new illustrations in this edition were made available.

THE AUTHORS

PREFACE TO THE FIRST EDITION

The authors of this book have long felt the need of a textbook covering both the theory and practice of the varied phases of the market milk industry. With the hope of meeting such a need, they have prepared this book, which contains the results of much original investigation and experience, as well as the best thought of others. Full acknowledgment has been made, wherever possible, of references to the work of other writers and investigators.

The business of producing and distributing market milk, with its present complexities, is a comparatively recent development of the dairy industry. For this reason there is need for a closer study and better correlation of its essential factors. It is the hope of the authors that this book may serve as a guide, not only to dairy students, but also to all others who are interested in the important problems confronting the producers and distributors of that most essential commodity—milk.

The authors wish to acknowledge their indebtedness to the United States Department of Agriculture, through whose courtesy many of the illustrations in this book were made available.

E. K.
C. E. C.

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MARKET MILK

CHAPTER I

MARKET MILK AN IMPORTANT INDUSTRY

Ancient history tells us that the cow has frequently been made an object of veneration and worship. She has been called the "foster mother of the human race"—a title which she has fairly earned, for no other animal has done so much to nourish the human family as she has. Her product is milk, a food intended by nature for promoting growth in the young.

"Market milk" is a term applied to milk consumed in its fluid state, in contradistinction to milk used for manufacturing products such as butter, cheese, ice-cream, etc. Far more milk is consumed in the fluid state than is used for any other purpose. It appears in this form upon almost every family table; it is the chief food of infants and growing children, and is also used by grown people, being especially useful in the diet of persons suffering from certain diseases.

The production and handling of market milk requires the highest type of scientific skill. Market milk must be produced economically and marketed expeditiously; from cow to consumer, it must be carefully guarded by sanitary measures, on account of its susceptibility to infection.

Originally, milk was consumed close to the source of production; the cow supplied the needs of her owner's family, with perhaps a small surplus for neighbors. Gradually, civilization became more complex and people clustered in cities, thus forming groups of "non-producers" of foods, the responsibility for whose nourishment rested upon the remaining agricultural population. As cities grew, dairying was pushed farther away from markets, so that a system had to be evolved to transport and distribute milk from the dairy farm to the consumer.

The introduction of the time element between production and con-

sumption, together with increased complexities in handling the milk, necessitated a rather elaborate system of sanitary control which called into play all the resources of the sanitarian and the bacteriologist. These factors, in connection with the magnitude of the business, have made the market milk industry one of the most highly specialized in agriculture.

Some figures on the growth and present size of the market milk industry may be of interest. Boston, Mass., was probably the first city in the United States to receive milk by railroad. This shipment occurred in 1838 and was so successful that, only five years later, one dealer in Boston received over 200,000 gallons of milk in one year. The first shipment of milk by rail into New York City was in 1847. From these small beginnings have grown our wonderful systems of transportation and distribution.

Present-day figures on the New York supply show the remarkable growth of the milk industry. In 1929 New York received a daily average of 3,832,600 quarts. This milk came from points between 44 and 450 miles distant, in New York, New Jersey, Vermont, Pennsylvania, Massachusetts, Connecticut and Canada. From the country the milk was transported by ten different railroads, although 30,000 gallons a day arrived by motor truck.

AMOUNT OF MILK PRODUCED AND USED

Reports show that there were 22,499,000 milk cows on farms in the United States on January 1, 1930 (see Table 1). These cows produce approximately 120 billion pounds, or nearly 14 billion gallons, of milk annually.

The largest quantity used for any single purpose is sold as market milk. Market milk requirements demand about 55 billion pounds, or nearly $6\frac{1}{2}$ billion gallons, of milk annually. While this may seem to be a tremendous volume of milk, we must remember that when it is divided among our population of over 120 million people the quantity per capita is not great. Estimates of the per capita consumption of dairy products in the United States are shown in Table 3.

PLACE OF DAIRY PRODUCTS IN THE AMERICAN DIET

It is estimated that dairy products constitute from 18 to 20 per cent of the total expenditure for food of the average American family. Economists and physiologists declare that dairy products should occupy

TABLE 1

Milk Cows and Heifers: Estimated Number and Value on Farms, January 1, 1928–1930, by States

State and Division.	Cows and Heifers 2 Years Old and Over Kept for Milk.								
	Number Jan. 1 (000 omitted).			Farm Value per Head Jan. 1			Total Farm Value Jan. 1 (000 omitted).		
	1928 (revised).	1929 (revised).	1930, Total.	1928.	1929.	1930.	1928.	1929.	1930.
Maine	139	135	138	$76.00	$87.00	$96.00	$10,564	$11,745	$13,248
New Hampshire	75	75	77	100.00	113.00	118.00	7,500	8,475	9,086
Vermont	286	288	294	97.00	100.00	101.00	27,742	28,800	29,694
Massachusetts	135	134	134	125.00	130.00	140.00	16,875	17,420	18,760
Rhode Island	20	21	21	132.00	142.00	150.00	2,640	2,982	3,150
Connecticut	108	109	111	130.00	140.00	141.00	14,040	15,260	15,651
New York	1,330	1,343	1,383	111.00	124.00	120.00	147,630	166,532	165,960
New Jersey	122	122	125	120.00	135.00	140.00	14,640	16,470	17,500
Pennsylvania	855	855	889	97.00	111.00	112.00	82,935	94,905	99,568
North Atlantic	3,070	3,082	3,172	105.72	117.65	117.47	324,566	362,589	372,617
Ohio	908	890	908	83.00	93.00	93.00	75,364	82,770	84,444
Indiana	679	693	721	75.00	85.00	84.00	50,925	58,905	60,564
Illinois	968	958	1,006	76.00	89.00	89.00	73,568	85,262	89,534
Michigan	849	849	866	87.00	99.00	99.00	73,863	84,051	85,734
Wisconsin	1,984	1,964	2,023	86.00	97.00	97.00	170,624	190,508	196,231
Minnesota	1,498	1,483	1,512	72.00	85.00	82.00	107,856	126,055	123,984
Iowa	1,314	1,314	1,340	76.00	86.00	85.00	99,864	113,004	113,900
Missouri	827	827	860	61.00	74.00	70.00	50,447	61,198	60,200
North Dakota	472	477	495	61.00	75.00	73.00	28,792	35,775	36,135
South Dakota	518	523	528	68.00	77.00	78.00	35,224	40,271	41,184
Nebraska	613	619	638	71.00	84.00	79.00	43,523	51,996	50,402
Kansas	701	708	722	62.00	75.00	74.00	43,462	53,100	53,428
North Central	11,331	11,305	11,619	75.33	86.94	85.70	853,512	982,895	995,740
Delaware	36	37	38	92.00	110.00	112.00	3,312	4,070	4,256
Maryland	185	187	193	85.00	97.00	100.00	15,725	18,139	19,300
Virginia	360	374	396	58.00	70.00	72.00	20,880	26,180	28,512
West Virginia	215	219	226	65.00	75.00	76.00	13,975	16,425	17,176
North Carolina	294	300	312	59.00	64.00	64.00	17,346	19,200	19,968
South Carolina	144	140	143	47.00	55.00	54.00	6,768	7,700	7,722
Georgia	343	343	350	42.00	49.00	49.00	14,406	16,807	17,150
Florida	78	74	78	37.00	46.00	55.00	2,886	3,404	4,290
South Atlantic	1,655	1,674	1,736	57.58	66.86	68.19	95,298	111,925	118,374
Kentucky	493	493	498	60.00	65.00	64.00	29,580	32,045	31,872
Tennessee	438	447	456	53.00	60.00	60.00	23,214	26,820	27,360
Alabama	350	350	353	40.00	46.00	48.00	14,000	16,100	16,944
Mississippi	390	390	410	40.00	45.00	47.00	15,600	17,550	19,270
Arkansas	375	382	400	42.00	48.00	48.00	15,750	18,336	19,200
Louisiana	204	202	204	36.90	49.00	47.00	7,344	9,898	9,588
Oklahoma	610	610	634	56.00	64.00	59.00	34,160	39,040	37,406
Texas	936	955	974	57.00	61.00	56.00	53,352	58,255	54,544
South Central	3,796	3,829	3,929	50.84	56.95	55.02	193,000	218,044	216,184
Montana	177	186	186	63.00	79.00	77.00	11,151	14,694	14,322
Idaho	170	173	178	75.00	86.00	80.00	12,750	14,878	14,240
Wyoming	72	73	72	70.00	86.00	84.00	5,040	6,278	6,048
Colorado	242	244	244	69.00	77.00	72.00	16,698	18,788	17,568
New Mexico	65	65	67	57.00	67.00	65.00	3,705	4,355	4,355
Arizona	35	36	35	85.00	95.00	95.00	2,975	3,420	3,325
Utah	92	97	100	73.00	87.00	82.00	6,716	8,439	8,200
Nevada	20	20	20	85.00	98.00	90.00	1,700	1,960	1,800
Washington	275	289	295	80.00	99.00	92.00	22,000	28,611	27,140
Oregon	214	220	220	72.00	88.00	80.00	15,408	19,360	17,600
California	614	626	626	80.00	94.00	94.00	49,120	58,844	58,844
Far Western	1,976	2,029	2,043	74.53	88.53	84.90	147,263	179,627	173,442
United States	21,828	21,919	22,499	$73.93	$84.63	$83.40	$1,613,639	$1,855,080	$1,876,357

a more prominent place in the diet; Dr. H. C. Sherman recommends that the food expenditure of the average family should be as follows:

	Per Cent.
Meat and fish	12
Milk and its products	44
Breads and cereals	13
Vegetables and fruits	17
Eggs	6
Sugar	3
Miscellaneous	5

TABLE 2

MILK USED IN MANUFACTURED PRODUCTS IN THE UNITED STATES, 1929

Manufactured Products.	Whole Milk Required per Unit of Product, Pounds.	1929.		
		Quantity of Product Manufactured, Pounds.	Whole Milk Required, Pounds.	Per Cent of Milk Manufactured.
Creamery butter	21	1,597,027,000	33,537,567,000	54.537
Farm butter	21	580,000,000	12,180,000,000	19.806
Cheese (all kinds)	10	483,933,000	4,839,330,000	7.870
Condensed and evaporated milk	2.5	2,206,648,000	5,516,620,000	8.971
Powdered milk	8	13,202,000	105,616,000	.172
Powdered cream	19	294,000	5,586,000	.009
Malted milk	2.2	22,850,000	50,270,000	.082
Milk chocolate	.....	.....	235,050,000	.382
Ice-cream (gals.)	13.75	365,448,000	5,024,910,000	8.171
Total whole milk required	.....	.....	61,494,949,000	100

Note: In addition, there were probably between 55 and 60 billion pounds of milk used as milk or cream for consumption in the households of the country, and about 8 billion pounds fed to animals, or wasted.

TABLE 3

PER CAPITA CONSUMPTION OF DAIRY PRODUCTS

Article.	Per Year.	Per Day.
Milk and cream	232.0 quarts	About $1\frac{1}{4}$ pints
Butter	17.61 pounds	" $\frac{3}{4}$ ounce
Cheese	4.62 pounds	" $\frac{1}{5}$ ounce
Ice-cream	3.0 gallons	" $\frac{2}{3}$ ounce

Dr. Graham Lusk, of the Cornell University Medical College, states that no family of five should buy meat until they have bought three quarts of milk per day.

We hear at times of a "surplus" of dairy products in certain sections. Such a surplus exists only because the American people do not use a sufficient amount of milk, butter, cheese, etc. If the diet of the American consumer were properly arranged, there would be no surplus dairy products.

TABLE 4

NUMBER OF MILK COWS IN THE UNITED STATES PER 1000 PERSONS

1840	287	1890	264
1850	278	1900	237
1860	276	1910	220
1870	234	1920	223
1880	251	1930	183

TABLE 5

BALANCE OF TRADE OF DAIRY PRODUCTS

Year.	Butter.			Milk Equivalent, Pounds.
	Exports, Pounds.	Imports, Pounds.	Net, Pounds.	
1928	3,897,857	4,659,136	761,279 im.	15,986,859 im.
1929	3,724,245	2,772,983	951,262 ex.	19,976,502 ex.
	Cheese.			
1928	2,599,947	80,432,272	77,833,325 im.	778,333,250 im.
1929	2,646,009	76,381,795	73,735,786 im.	737,357,860 im.
	Condensed and Evaporated Milk.			
1928	115,413,722	2,608,870	112,804,852 ex.	282,012,130 ex.
1929	109,184,425	2,634,057	106,550,368 ex.	266,375,920 ex.
	Combined Butter, Cheese, and Condensed and Evaporated Milk.			
1928	.....			512,307,979 im.
1929	.....			451,005,438 im.

COWS PER 1000 PERSONS IN THE UNITED STATES

The pitifully scant consumption of dairy products is shown by the figures in Table 3. Nearly six people depend upon each dairy cow for all that they consume of milk, butter, cheese, condensed milk, ice-cream, etc. (See Table 4.) These six people do not even get all of the milk from one cow, for we export some of her milk in various forms to other countries, as shown in Table 5.

ADVANTAGES OF MILK

The principal advantages of milk as a food are the following: It requires no cooking or other preparation; it is readily and thoroughly digested by the average person; it is a complete food, containing all the constituents (except sufficient iron) necessary for body building and maintenance; it is well-balanced in that it furnishes food materials in desirable proportions; it contains no waste materials, such as shell, bone or skin; it contains "vitamins" or growth-promoting accessories; and it is usually cheaper than other foods possessing similar characteristics.

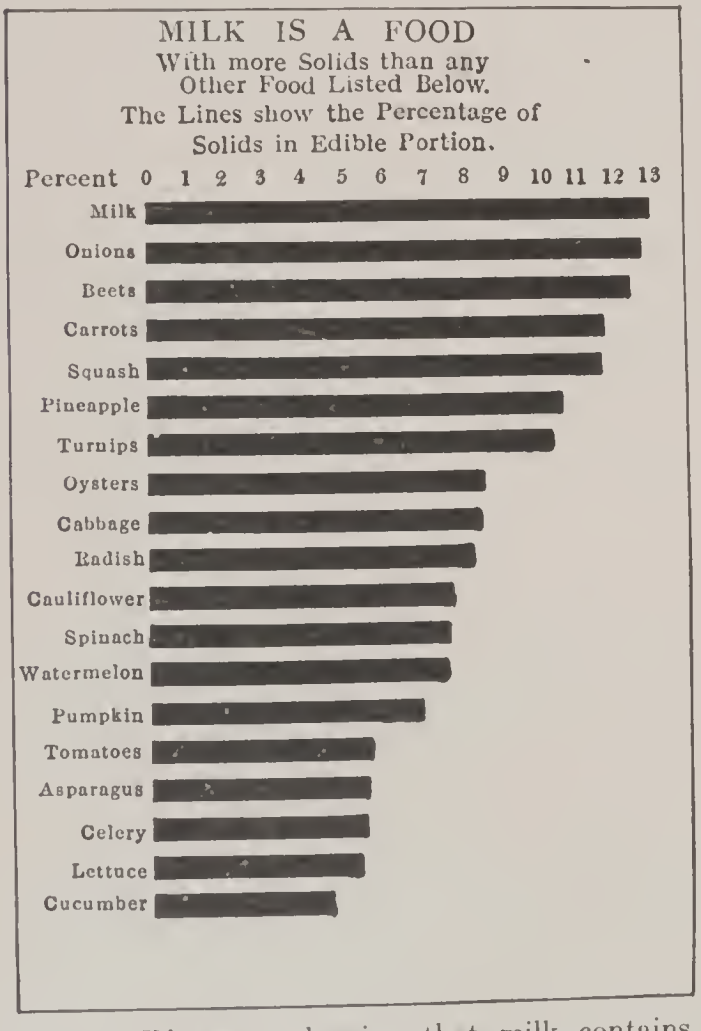

FIG. 1.—Diagram showing that milk contains more solids than some other foods. Milk is not only a beverage, but a real food. U. S. Dept. of Agriculture.

MILK A REAL FOOD

Because milk is a fluid and cannot be chewed as can steak or vegetables, many persons think of it only as a beverage. In spite of this rather general belief, milk contains more actual solid materials than do many of the well-known "solid" foods. Fig. 1, issued by the United States Department of Agriculture, shows the fallacy of considering milk as a beverage.

REFERENCES

Larson and Putney, Dairy Cattle Feeding Management.

The Agricultural Situation for 1918. Part II, Dairying. Office of the Secretary. Circular 85, U. S. Depart. Agri.

Imports and Exports of Agricultural Products. Yearbook Separate 864, U. S. Dept. Agri., 1920.

Livestock, 1920. Yearbook Separate 863, U. S. Dept. Agri., 1920.

Pirtle, Trend of the Dairy Cattle Industry in the United States and Other Countries. Dept. Circular 7, U. S. Dept. Agri.

Miscellaneous Agricultural Statistics. Yearbook Separate 865, U. S. Dept. Agri.

Merritt, The Production and Consumption of Dairy Products. Dept. Bul. 177, U. S. Dept. Agri.

Pirtle, Supplement to Handbook of Dairy Statistics, U. S. Dept. Agri.

CHAPTER II

MILK AS A FOOD

FUNCTIONS OF THE FOOD CONSTITUENTS

Protein.—Under this head are included the nitrogenous portions of milk, mainly the casein and albumin. Similar substances are lean meat and the white of eggs. Atwater states that protein forms about 18 per cent, by weight, of the human body; it is perhaps the most important of all food constituents. It is used for building flesh (lean), muscle, tissues, bones and body fluids; thus it is important not only for providing growth, but for repair of waste. Protein may also be burned in the body to produce energy.

Fats.—Fats in food may be burned for energy, or they may be stored in the body as fat or fatty tissue. About 15 per cent, by weight, of the average human body is fat.

Carbohydrates.—Carbohydrates include mainly sugars and starches. In milk, the milk sugar is the only carbohydrate of any importance. Carbohydrates are similar in use to fats. They may be burned to furnish energy, or they may be stored as fat in the body. Carbohydrates form less than 1 per cent of the weight of the body.

Ash.—Ash, or mineral matter is the main constituent of bones and teeth. It is also found in tissues and body fluids. Ash is the non-combustible food material. It constitutes from 5 to 6 per cent of the weight of the body.

ENERGY AND FUEL VALUE

Proteins, carbohydrates and fats can be burned in the body to yield energy, which may be expended either as power to perform work or as heat. Energy is produced by the oxidation of fuel foods in the body. Special types of apparatus have been devised for measuring the fuel values of foods. Experiments have shown that every gram of protein or carbohydrates furnishes 4 calories, while a gram of fat supplies 9 calories. As 453.6 grams equal a pound, it will be seen that a pound of

protein or carbohydrates supplies 1820 calories, while a pound of fat supplies 4040 calories.

A calorie is a unit used for measuring the energy supplied by foods. One calorie represents the amount of heat necessary to raise 1 pound of water 4° F. In measuring power, a calorie represents the power needed to lift 1 ton a distance of 1.54 feet.

The amount of energy supplied by foods is remarkable. Some of the energy is necessary for performing internal work, such as breathing, and some is required to maintain body heat. Energy is required for all external muscular work, such as walking, swimming, etc. One quart of 4 per cent milk would furnish about 670 calories, if all the protein, carbohydrates and fats were burned in the body. These 670 calories, if used entirely for heat, would melt 15 pounds of ice and raise the resultant water to the boiling point. Or, in terms of power, the energy in a quart of milk would raise 2 tons a distance of 520 feet.

PROTEIN AND ENERGY REQUIREMENTS OF HUMANS

Many studies have been made to determine the food requirements of human beings who perform various amounts of physical labor. Certain amounts of protein must be eaten to maintain the body and repair waste; sufficient carbohydrates and fats must be combined with the protein to furnish enough energy to supply body heat and perform muscular work. The following table, from Atwater, shows a dietary standard for American men and women. (1)

Dietary Standard.	Actually Eaten.			Fuel Value.	Nutritive Ratio.
	Protein.	Fat.	Carbohydrates.		
	Grams.	Grams.	Grams.	Calories.	
Man with very hard muscular work	175	*a*	*a*	5500	7.2
Man with hard muscular work	150	*a*	*a*	4150	6.2
Man with moderately active museular work	125	*a*	*a*	3400	6.2
Man with light to moderate muscular work	112	*a*	*a*	3050	6.1
Man with "sedentary" or woman with moderately active work	100	*a*	*a*	2700	6.1
Woman at light to moderate muscular work or man without muscular exereise	90	*a*	*a*	2450	6.1

(*a*) Fats and carbohydrates in suffieient amounts to furnish, together with the protein, the indieated amount of energy.

Other writers give somewhat lower protein requirements. In some cases the protein standard is only 60–75 grams per day for an average man.

PROTEIN AND ENERGY FURNISHED BY MILK

The energy furnished by a given quantity of milk can be readily figured if its percentage of fat and solids-not-fat is known. To do this, subtract the percentage of ash (which is fairly constant at .72) from the solids-not-fat. The remainder will be the percentage of protein and carbohydrates in the milk. We have already seen that each gram of fat furnishes 9 calories and each gram of carbohydrates or protein furnishes 4 calories. A quart of average milk weighs approximately 975 grams. From these figures the following table has been worked out:

Fat. Per Cent.	Solids-not-fat. Per Cent.	Solids-not-fat, Minus Ash. Per Cent.	Calories in Fat of 1 Quart Milk.	Calories in Solids-not-fat of 1 Quart Milk.	Total Calories in 1 Quart Milk.
3	8.33	7.61	263.3	296.8	560.1
4	8.79	8.07	351.0	314.7	665.7
5	9.10	8.38	438.0	326.8	765.6

A quart of milk contains between 25 and 40 grams of protein, and a fair average may be stated as 30 grams.

From Atwater's figures it thus appears that about 4 quarts of milk a day would furnish enough protein, and 5 quarts a day enough energy, for a man at moderately active muscular work. While milk is the sole or chief food of infants, it is also valuable as part of the diet for older children and adults.

MILK AS A "BALANCED" FOOD

A "balanced" food is one which supplies the various nutritive substances in quantities proportioned to the needs of the body. A well-balanced food preserves a proper ratio between protein, fat, carbohydrates, mineral matter and total energy. Milk is such a food, and would alone support life for long periods; its bulkiness, however, precludes its use as the sole food of healthy adults engaged in hard work.

DIGESTIBILITY OF MILK

Composition tables alone do not give us a complete knowledge of the nutritive value of foods; we must also know how much of the protein, fats, etc., is digestible, for it is only the digestible portions which can nourish us. Experiments made in the United States Department of Agriculture (2) show that milk is very thoroughly digested, in fact, more

completely so than the average of other animal foods. Persons who digest milk well can assimilate 98 per cent of the milk protein and 99 per cent of the fat and carbohydrates. Milk is digested more completely when it is taken with other foods than when it is taken alone.

VITAMINS

Within comparatively recent years, nutrition experts have discovered that the growth-promoting and protective value of foods depends not so much on their various chemical compounds as on certain substances or groups of substances which have been designated by the term "vitamins." These vitamins are still "unknown" substances in that they have never been analyzed; but their action has been very carefully studied. F. G. Hopkins of Cambridge University, England, T. B. Osborne and L. B. Mendel of Yale University, and E. V. McCollum of the University of Wisconsin and Johns Hopkins University were the earliest investigators in this field.

Kinds of Vitamins.—Present knowledge indicates that there are at least five vitamins which have been termed A, B, C, D, and E. Recently certain investigators have tentatively announced that what has been called vitamin B really consists of two separate vitamins which it is proposed to term vitamins B_1, or F; and B_2, or G.

Functions of Vitamins.—Each vitamin plays some particular part in nutrition or the prevention of various pathological conditions known as "deficiency diseases." Briefly, the function of each vitamin is as follows: (14)

Vitamin A protects against xerophthalmia, ophthalmia, and certain bacterial infections. Lack of this vitamin in the food supply leads to weakening of many body tissues, failure to make normal growth, and inflammation of the eyes, ears, and sinuses. This vitamin is abundant in the fat of milk.

Vitamin B is essential for the maintenance of growth, proper digestion, and resistance to infection. Its more definite functions will be discussed under vitamins F and G, its components. Milk is a good source of vitamin B.

Vitamin C is the anti-scorbutic vitamin which protects from scurvy. It is usually present in milk.

Vitamin D is anti-rachitic. It prevents rickets by aiding the assimilation of lime and phosphorus, thus promoting proper bone formation. It is present in milk in small but appreciable amounts.

Vitamin E is called the reproductive or anti-sterility vitamin. It is essential for the proper functioning of reproduction processes. Small amounts of this vitamin are found in milk.

Vitamin F, or B_1, is the anti-neuritic vitamin. Its definite work

is to prevent polyneuritis in fowls and some other animals, and probably beriberi in man.

Vitamin G, or B_2, is generally supposed to prevent pellagra in the human family. It is found in milk in relatively greater proportions than is vitamin F.

Vitamins in Dairy Products.—All dairy products contain vitamins, but more kinds and usually greater amounts of the various kinds are carried in whole milk and whole milk products such as condensed and evaporated whole milk and dried whole milk.

Effect of Heat on Vitamins.—In experimental work vitamins A, D, and G or B_2, seem to be quite stable in withstanding heat. Vitamin F, or B_1, is apparently more susceptible to heating.

Authorities differ somewhat regarding the effect of heat on C; but it is quite generally conceded that its properties are injured or destroyed by subjection to high temperatures in the presence of air. C appears to be most abundant in fresh milk and to be impaired or destroyed, probably by oxidation, as milk ages.

Importance of Vitamins in Milk.—The following quotations, taken from McCollum's "The Newer Knowledge of Nutrition," (3) show the importance of milk in the diet:

"Milk is, however, without doubt our most important food-stuff. This is true, because the composition of milk is such that when used in combination with other food-stuffs of either animal or vegetable origin, it corrects their dietary deficiencies.

"Milk and the leaves of plants are to be regarded as protective foods and should never be omitted from the diet. Milk is a better protective food than are the leaves, when used in appropriate amounts."

UNDERNOURISHMENT IN CHILDREN

The statement has been made by reliable authorities that about one-third of all American babies and school children are undernourished. Not all undernourishment is due to lack of milk in the diet; but the well-known necessity of milk for children, coupled with recent investigations showing the vast numbers who do not have milk regularly, force the conclusion that much of the undernourishment in children is due to lack of milk in the diet. Investigations made by the Children's Bureau of the Department of Labor in 1919 showed that only 29 per cent of 728 Baltimore children between two and seven years of age had fresh milk to drink. In Washington, investigators of the same bureau found 50 per cent of children, in the same age group, without milk. In California, a survey conducted by the State Dairy Council in 1919 (4) showed that nearly 41 per cent of 129,633 school children did not receive milk daily.

During the War and coincident with the increasing price of milk and

other foods, the use of milk by children in New York city decreased; at the same time undernourishment increased, as shown by the following table compiled from figures published by the Department of Health.(5)

UNDERNOURISHMENT IN SCHOOL CHILDREN

Year.	Per Cent Undernourished.
1914	5.0
1915	6.0
1916	11.0
1917	21.0
1918	19.0

Explanation of these figures is found in further studies in the same city. It was found that in 2200 families, each having at least two children under six years of age, 2148 children (under six years) were drinking tea or coffee in place of milk. The investigators conclude, "There can be no question but that a great deal of this undernourishment is due to the fact that children are not getting sufficient milk in their diet."

Tables 6 and 7 contain partial reports of school surveys held in two cities not far apart. These surveys were made cooperatively by the Dairy Division, U. S. Department of Agriculture, the State Agricultural Colleges and the city schools.

TABLE 6

PARTIAL REPORT OF SCHOOL SURVEY IN NEW ORLEANS, LOUISIANA, APRIL, 1922

School.	Number Children Reporting.	Amount of Milk Consumed Daily.					Number Drinking Milk Occasionally.	Number Drinking Tea or Coffee Daily	Number Drinking Tea or Coffee Occasionally.	Number Drinking Soft Drinks Daily.	Number Soft Drinks Occasionally.	Number Under W'ght.
		Number Drinking Milk Daily	More than Three Cups.	Three Cups Daily.	Two Cups Daily.	One Cup Daily.						
White, Public..	15,772	7746	839	1388	3515	3493	8,446	10,982	4688	2421	15,297	11,604
White, Catholic	2,128	955	97	169	357	331	698	1,543	417	220	1,603	991
Negro, Public..	728	280	11	23	86	166	393	446	175	71	625	360
Negro, Catholic	651	144	3	12	32	72	291	444	114	42	433	218
Total.	19,278	9125	950	1592	3990	4062	10,028	13,415	5394	2712	17,958	13,713

TABLE 7

PARTIAL REPORT OF SURVEY TAKEN IN JACKSON, MISS., MILK FOR HEALTH CAMPAIGN, APRIL, 1922

TOTAL WHITE PUBLIC SCHOOLS

Number Children Reporting.	Number Children Drinking Milk Daily.	Number Children Having Two Cups or More Daily.	Number Children Having Milk Occasionally.	Number Children Having Tea or Coffee Daily.	Number Children Having Tea or Coffee Occasionally.	Number Children Underweight.	Number Children 10 Per Cent or More Underweight.
1977	1234	1075	562	426	781	988	415

1. 62.4 per cent have milk daily.
2. 45.6 per cent have less than two cups daily (or 902 children).
3. 9.1 per cent have no milk (or 181 children).
4. 21.5 per cent have tea or coffee daily.
5. 21 per cent are 10 per cent or more than 10 per cent underweight.

MILK FOR INFANT FEEDING

Mother's milk is by far the best food for babies, and no substitute can entirely take its place. Bottle-fed children die at a greater rate than do those nursed at the breast. This is due largely to the fact that the milk of other animals differs chemically and physically from human milk and the stomach of the human infant does not tolerate it so well. Furthermore, milk nursed from the breast is practically sterile, whereas other milk is often seriously contaminated through carelessness, age or high temperatures.

Human Milk and Other Milk.—The following table shows how human milk differs in composition from the milk of other mammals.

COMPOSITION OF MILKS (Gowen and others)

Animal.	Fat, Per Cent.	Solids-not-fat, Per Cent.	Total Solids, Per Cent.
Human	3.28	8.50	11.78
Cow	3.44	8.61	12.05
Goat	3.54	8.26	11.80
Ass	.90	8.82	9.72
Mare	.99	8.93	9.92
Indian buffalo	6.77	9.47	16.24
Ewe	7.17	11.35	18.52
Sow	6.60	11.91	18.51
Bitch	5.65	10.24	15.89
Reindeer	22.46		
Caribou	10.63		
Water buffalo	12.46		

Cow's milk is the almost universal substitute for mother's milk. Where available, goat's milk is frequently used, and ass's and mare's milk is sometimes used. A complete analysis of the most common substitutes is as follows:

	Water.	Fat.	Sugar.	Protein.	Ash.
Human	87.30	4.00	7.00	1.50	.20
Cow	87.50	3.50	4.30	4.00	.70
Goat	86.78	4.07	4.64	3.76	.75
Ass	90.05	1.00	6.75	1.75	.45

It will be seen that cow's milk contains less sugar and more protein than human milk. Ass's milk is very low in fat, but closely approximates human milk in the other constituents. Any substitute for mother's milk must be " modified " for young infants, to make its composition coincide as nearly as possible with that of breast milk. The methods of modification will be discussed later.

Many physicians believe that goat's milk is better adapted than cow's milk for infant feeding; actual experiments, however, do not seem conclusive on this point. Sherman and Lohnes (6) fed a number of hospital and asylum infants on both kinds of milk. At a certain interval after feeding, they recovered the stomach contents, which averaged 41 cubic centimeters of the cow's milk and 27 cubic centimeters of the goat's milk; from this they conclude that goat's milk is more rapidly digested. They also state that the curds from goat's milk were smaller and more flocculent. However, deductions based on absorption and gain in weight were inconclusive; of sixteen infants fed similar formulas, twelve gained better on cow's milk, and only four gained better on goat's milk.

Previous to the World War, a herd of fifteen or sixteen milch asses was maintained by Welford & Sons, England, for the purpose of supplying milk for infant feeding in wealthy families. Each ass yielded about one quart of milk daily, and this was sold for about $1.50. Dr. P. B. Tustin, of London, who kindly supplied the above information, further states, " Undoubtedly the chief difference between ass's milk and cow's milk lies in the value of the protein, as the addition of acid produces in the former only a barely perceptible, exceedingly fine precipitate, and the coagulum with rennet is of a soft flocculent character, rendering its digestion rapid and easy.

" . . . Being very rich in albumin, ass's milk cannot be sterilized and should on no account be boiled before use."

Condensed and Evaporated Milks.—Considerable amounts of the sweetened condensed and unsweetened evaporated milks are used for infant feeding. Canned milk is useful in regions where fresh cow's milk is not available or where the milk supply is not fit for infant feeding; but it should always be supplemented by orange juice or some other anti-scorbutic substance.

Its portability and low bacterial content have been its chief advantages. Some authorities claim excellent results with both condensed and evaporated milks; others declare the sweetened product unsuitable for young infants. Washburn and Jones (7) conducted experiments with young pigs and reason from their results that evaporated milk is satisfactory, but that sweetened condensed milk is thoroughly undesirable. The latter produced deficient bone formation and a dangerously fat body.

The Connecticut Experiment Station, at New Haven, gives the following as the result of analyses extending from 1904 to 1919 (12).

Composition of Evaporated Milks. Per Cent

	Water.	Ash.	Protein.	Milk Sugar.	Fat.	Calories per 100 Grams.
Maximum	75.27	1.85	8.75	11.99	10.20	164
Minimum	68.93	1.29	6.38	8.10	5.61	121
Average	72.78	1.57	7.26	10.26	8.24	145

Composition of Condensed Milks. Per Cent

	Water.	Cane Sugar.	Ash.	Protein.	Milk Sugar.	Fat.	Calories per 100 Grams.
Maximum	31.72	45.21	2.16	9.81	17.42*	10.17	355
Minimum	21.67	26.99	1.50	6.95	10.42	6.90	312
Average	26.62	40.34	1.80	8.29	14.00	8.95	332

* One sample contained 24.68 per cent, but this was probably due to a partial inversion of cane sugar.

It will be seen from these tables that there is a considerable variation in composition between various brands. This emphasizes the

importance of knowing the analysis of the particular brand used in infant feeding; otherwise overfeeding or underfeeding may result, as pointed out by Jordan (13).

Condensed and evaporated skim milks are deficient in fat and should not be used for infant feeding except by the express order of a physician. Neither should concentrated milk which has had other fat substituted for butter-fat be used for infants or young children.

Dried and Powdered Milks.—Both skim and whole milk may be had in dried or powdered form. Different brands vary in composition, but the following table gives an average of several commercial grades:

Composition of Milk Powders. Per Cent

	Water.	Ash.	Protein.	Fat.	Lactose.	Calories per 100 Grams.
Whole milk.....	1.50	5.75	26.67	28.20	37.88	512
Skim milk.....	4.45	8.12	35.03	2.28	50.11	361

Whole-milk powder has been used very successfully in infant feeding both here and in Europe; skim-milk powder to which butter-fat has been restored has also proved satisfactory. In an English report compiled by Coutts (8) and submitted to the Local Government Board, the statement is made that whole-milk powder is a very valuable infant food as a substitute for breast feeding. Infants fed on milk-powder solutions made normal weight increases and had firm, healthy bodies; sickly children also did well on such mixtures. No scurvy or rickets were observed, and teething and walking were normal. Bacterial tests showed only a small number of organisms, and *B. coli* was found in only two samples out of eighty-eight examined.

Feeding experiments carried on in Boston, Mass., under the direction of the U. S. Public Health Service,(9) coincide with the British findings. Children fed on reconstituted whole-milk powder, and on milk reconstructed from skim powder and butter, showed normal gain in weight. No deleterious results were observed which might be attributed to the powder.

Malted Milks and Proprietary Infant Foods.—Considerable use, in infant feeding, has been made of malted milks and special infant foods, such as Mellin's Food, Eskay's, Nestlé's, Imperial Granum, etc. These foods are nearly all deficient in fat and relatively high in proteids and

carbohydrates. The following table gives analyses, made by the Connecticut Station in 1915, of four brands of malted milk.

Composition of Malted Milks. Per Cent.

	Water.	Fat.	Fiber.	Ash.	Carbo-hydrates.	Protein.	Calories per 100 Grams.
Brand A....	5.93	6.75	.13	3.08	70.05	14.06	397
" B....	5.18	7.15	.05	3.45	68.79	15.38	401
" C....	2.03	8.10	.15	4.00	70.72	15.00	416
" D...	3.20	5.20	.30	3.28	73.52	14.50	399
Average..	4.09	6.80	.16	3.45	70.77	14.74	403

The analysis of one prominent brand of infant food as given by its manufacturers in 1920 is appended.

Composition of Mellin's Food. Per Cent

Fat	.16	
Protein	10.35	
Maltose	58.88	Soluble carbohydrates 79.57
Dextrins	20.69	
Salts	4.30	
Water	5.62	
	100.00	

The special infant foods usually contain added maltose, albumen or mineral salts. Owing to their composition, they are usually used in conjunction with fluid cow's milk for infant feeding.

Grades of Cow's Milk.—The grades of milk best suited for children are certified, properly pasteurized, and boiled. Certified milk is raw milk produced under the rigid supervision of a medical milk commission; it is the safest grade of raw milk, and must contain less than 10,000 bacteria per cubic centimeter. Properly pasteurized milk is clean milk which has been heated to at least 142° F. for thirty minutes.

No matter what sort of milk is used, no pains should be spared to make sure that the inspecting bodies are competent and that the milk is

really of high grade. This applies to milk which is to be heated as well as to that used raw.

Some physicians prefer raw milk for infant feeding, claiming that heated milk is deficient in anti-scorbutic properties. However, such a deficiency can be easily remedied in the diet.

Modification of Cow's Milk.—As cow's milk contains much more protein and mineral matter than human milk and only about half as much sugar, its composition must be changed, or "modified" to suit it to infant feeding. This modification consists, in the main, of diluting the milk with water to decrease the protein, and then adding cream and sugar.

This is usually done in the home under a physician's direction. There are, however, milk stations where milk is modified commercially; such stations are operated in many cities by the Walker Gordon Laboratory Company. At these stations, milk is modified according to the physician's prescription; the feedings for one day are placed in sterile nursing bottles and delivered packed in ice.

As previously stated, milk for infants should be of the best grade. The mixed milk from a herd of cows is better than milk from an individual cow, because there is less variation in its composition. The size of the fat globules in the milk of different breeds of dairy cattle is not, apparently, an important factor in infant feeding. The milk of any breed can be satisfactorily modified, but it is essential to know the exact composition of the milk which is used. Normal infants digest well milk containing 2 to $3\frac{1}{2}$ per cent fat.

Many mothers are unable to nurse their babies, except for a very short period. Normally, however, weaning should be begun at nine to ten months and be complete when the child is one year old. When weaning starts, the modification must be weak until the infant becomes accustomed to it. Holt states (10) that an infant weaned at nine or ten months must be started on the same strength as a four- or five-months' old bottle-fed baby.

There are two general methods of modifying cow's milk. One consists of formulas using "top milk," while the other uses whole milk. "Top milk" should contain about 7 per cent fat and is obtained by using the upper half of average milk or the upper two-thirds of very rich milk, after the cream has risen. Whole milk formulas are being used more extensively because of the greater uniformity of composition.

The amount of water used in the dilution is not so important as the total amount of food given the infant. If too much is given,

the infant is likely to vomit; while if too little is supplied, undernourishment will result. No definite rules can be laid down for infant feeding; the weight, age, vigor, etc., of the child must be studied in each case.

Hess states (11) that an infant should receive $1\frac{1}{2}$ to 2 ounces of milk in dilution for each pound of body weight; this would supply about $1\frac{1}{2}$ to 2 grams of protein per pound of weight. Children should be supplied with definite amounts of energy in their foods, as follows:

Average infant	under	two	months	30 to 45	calories	per	pound	body weight
"	" over	"	"	45 to 55	"	"	"	
Thin	" under	"	"	50 to 65	"	"	"	
"	" over	"	"	55 to 70	"	"	"	

Milk sugar is generally added to make up the deficiency in carbohydrates. Cane sugar may be used, according to Holt, but in this case the amount required is only about two-thirds as great as in the case of milk sugar. Maltose and dextrin are very useful as a source of sugar, the former being especially easy to digest and slightly laxative. If either of these is used to replace milk sugar, the amount used should be increased by about one-fourth.

The following table, adapted from Holt, (10) indicates, in general, the method of modifying 4 per cent whole milk for normal infants.

FORMULAS WITH 4 PER CENT WHOLE MILK (Holt) (10)

Age.	Birth. to 1 Wk.	1 to 2 Wks.	2 to 3 Wks.	3 to 4 Wks.	4 to 5 Wks.	5 to 7 Wks.	7 to 9 Wks.	9 to 11 Wks.	11 to 13 Wks.	3 to 4 Mos.	4 to 5 Mos.	5 to 6 Mos.	6 to 8 Mos.	8 to 10 Mos.
Milk, oz.	6	6½	7	7½	8	8½	9	9½	10	11	12	13	14	15½
Sugar, oz.	1	1	1	1	1	1	1	¾	¾	½	½	½	½	½
Water, oz.....	14	13½	13	12½	12	11½	11	10½	10	9	8	7	6	4½
Flour, tablespoons	0	0	0	0	0	0	0	½	1	1½	1½	1½	2	2
Total..	20	20	20	20	20	20	20	20	20	20	20	20	20	20

Flour: Barley, oat, rice, wheat or arrowroot, cooked for half an hour in part of the water. If top milk is used, use one-third to one-fourth less milk in each formula.

Of the above formulas, approximately the following amounts are fed:

AMOUNT AND FREQUENCY OF FEEDINGS (Holt) (10)

Age.	Number of Feedings in 24 Hours.	Quantity of Food in Ounces.	
		Each Feeding.	24 Hours.
2d–7th days	7	1–2	7–14
2d–3d week	7	2–3½	14–24
4th–6th week	7	3–4	21–28
7th week–3d month	7	3½–5	25–35
3d–4th month	6	4½–6	27–36
4th–6th month	6	5½–6½	33–39
6th–12th month	5	7–8	35–40

REFERENCES

(1) Atwater, W. O., Principles of Nutrition and Nutritive Value of Food. F. B. 142. U. S. Dept. Agri.

(2) Milk and Its Uses in the Home. F. B. 1207. U. S. Dept. Agri.

(3) McCollum, E. V., The Newer Knowledge of Nutrition. The MacMillan Co., N. Y.

(4) California Dairy Council. Quarterly Bulletin, Vol. 1, Nos. 2 and 3, Jan., 1920.

(5) School Health News. Dept. of Health, City of N. Y., Vol. V, No. 5, May, 1919.

Sherman and Gillett, The Adequacy and Economy of Some City Dietaries. Pub. No. 121. The N. Y. Ass'n for Improving the Condition of the Poor.

(6) Sherman and Lohnes, Practical Study of Goat's Milk in Infant Feeding as Compared to Cow's Milk. Journal Am. Med. Assn., Vol. LXII, No. 23 .

(7) Washburn and Jones, Studies of the Values of Different Grades of Milk in Infant Feeding. Vt. Agri. Exp. Sta., Bulletin 195.

(8) Coutts, F. J. H., Report to the Local Government Board (England) on an Inquiry as to Condensed Milks. New Series No. 56. Food Reports No. 15.

(9) Eighth An. Rept. Int. Assn. of Dairy and Milk Inspectors, 1919. Report of Committee on Remade Milk. Part III, Results of Feeding Infants on Remade Milk.

(10) Holt, The Care and Feeding of Children. D. Appleton & Co., N. Y.

(11) Hess, Principles and Practice of Infant Feeding. F. A. Davis Co., Phila., Pa.

(12) Street, Condensed or Evaporated Milks, Malted Milks, and Milk Powders.

(13) Jordan and Mott, Condensed Milk and Its Value for General Use and for Infant Feeding. Am. Journal of Public Hygiene, Vol. XX. No. 2.

(14) Smith, Sybil L., Vitamins in Food Materials. Circ. 84, U. S. Dept. Agri.

Goat Milk for Babies. Bulletin 429, N. Y. (Geneva) Exp. Sta.

Chapin, Theory and Practice of Infant Feeding.

Reports to the Local Government Board on Health and Medical Subjects. (New Series No. 116.) Some Investigations Bearing on the Nutritive Value of Dried Milk. Food Reports, No. 24.

Bosworth and Van Slyke, The Casein and Salts of Goats' Milk. N. Y. (Geneva) Exp. Sta. Tech. Bul. 46.

Smith and Sherman, The Vitamines.
Lusk, Graham, Food in War Times. The Scientific Monthly, Oct., 1917.
Milk as a Food. Leaflet, U. S. Dept. Agri.
Overman, O. R., Food Values and Dairy Products. Circ. 235, Ill. Agri. Exp. Station.
Ferry, Edna L., The Food Value of Milk. Bulletin 215, New Haven (Conn.) Agri. Exp. Station.
Wisconsin Agri. Exp. Sta., Res. Bulletin 17.
Journal Biol. Chem., XXIV, 491, 1916.
Sherman, H. C., The Chemistry of Food and Nutrition.
Lusk, Elements of the Science of Nutrition.
Chittenden, The Nutrition of Man.
Atwater, Methods and Results of Investigations on the Chemistry and Economy of Foods. Bulletin 21, Office of Exp. Sta., U. S. Dept. Agri.
Roberts, Lydia, What is Malnutrition? Bureau Publication No. 59, Children's Bureau, U. S. Dept. Labor.
Funk, The Vitamines.
Hart and Steenbock, Milk Necessary for the Nation's Welfare. Bul. 291, Wis. Exp. Sta.

CHAPTER III

MILK AND PUBLIC HEALTH

Bacteria are often called both friends and foes of the dairy industry. Certain types are useful in the manufacture of special products, where desirable flavors are produced by bacterial growth. In the field of market milk, however, bacteria are always foes; they sour milk, produce unpalatable flavors, and may be the cause of sickness and death. The latter point, namely, the relation of milk to public health, is of the utmost importance. Our greatest efforts, in the laboratory and in the field, have been directed toward the protection of market milk from bacterial invasion and multiplication.

For a great many years it has been recognized that there is a close association between dirty, carelessly handled milk and human health. This belief was held even before bacteriology was developed to prove the case. Modern research has shown us that specific bacteria cause specific disease; and, furthermore, we now know that these disease-producing bacteria may be carried in milk. Fortunately, milk-borne epidemics are relatively few; but those that occur cause needless suffering and death, and nothing should be left undone to prevent them. It is undoubtedly the case that numerous epidemics have been laid to milk where milk was not actually the causative agent. It is not sufficient to find a large number of cases among the customers of one dairy; the ratio of disease cases to the amount of milk delivered must be ascertained. It is necessary also to trace the infection to its source and find the contaminating agency, before the fault can be surely attributed to milk. Other foods and water ingested by the stricken ones must also be carefully investigated.

Trask (1) has tabulated 260 milk-borne epidemics and has compiled 240 more reported by others. Their history goes back as far as 1857. Savage reports a milk-borne diphtheria epidemic occurring in England in 1878. Of the epidemics tabulated by Trask, the following incidence was observed:

Typhoid fever	179
Scarlet fever	51
Diphtheria	23
Septic sore throat	7
	260

Armstrong and Parran (2) have taken Trask's figures and brought them up to January 1, 1927, as shown in Table 8.

TABLE 8

Recorded Milk-borne Outbreaks (All Types) in the United States by Five-year Periods, January 1, 1881, to January 1, 1927

Years.	Outbreaks.	Years.	Outbreaks.
1881–1885.....	3	1911–1915.....	238
1886–1890.....	14	1916–1920.....	130
1891–1895.....	26	1921–1925.....	130
1896–1900.....	33	1926.....	12
1901–1905.....	60		
1906–1910.....	145	Total.....	791

"The decrease since 1914 is probably due, in part at least, to improvement in the quality of our milk supply. * * *

"When we consider the magnitude of the milk industry and the value of its product to the public, this considerable collection of milk-borne illnesses herein reported shrinks in comparison and offers no adequate grounds for advising any general curtailment in the use of milk and its products. Yet the occurrence of milk-borne diseases is a challenge to health authorities, milk producers, and milk handlers, and demands correction."

TUBERCULOSIS

There is now little doubt that bovine tuberculosis, or tuberculosis of cattle, can infect the human family. Schroeder, one of the foremost authorities on bovine tuberculosis, states (3) that, " tuberculosis among dairy cows is one of the greatest dangers to which public health is exposed, and that every effort should be made, by those who have the welfare of humanity at heart, to correct this great evil." Park, Krumweide and co-workers declare (4) that, " a careful study of all the factors leads us to estimate that about 10 per cent of all deaths caused by tuberculosis, in children under five years of age, is due to infection through drinking raw cow's milk." This statement was made after a careful study of 1042 cases of tuberculosis in children, where the bovine type of organism was found. In 1038 of the cases the bovine type was found, while in 4 cases both bovine and human types occurred. Tuberculosis in very young children is frequently of the bovine type and is most often found in the digestive system and as cervical adenitis. This strongly supports the statement that tuberculosis is frequently due to the ingestion of infected milk.

The bovine and the human tubercle bacilli differ in morphology; and this fact led earlier investigators to assume that they were separate and

distinct. The theory has been advanced that the bovine type of organism, when taken into the human system, undergoes, in time, certain changes due to altered environment, until it assumes the human type. Indeed, Von Behring states that adult tuberculosis is frequently the result of early infection which has lain dormant for some time. In this way, the bovine type of organism might be introduced into the digestive tract of an infant. After remaining dormant for a long time, perhaps for years, the organism might work its way through the tissues and appear as the human type in another part of the body.

TYPHOID FEVER, SCARLET FEVER, DIPHTHERIA AND SEPTIC SORE THROAT

A number of cases and outbreaks of typhoid fever, scarlet fever, diphtheria and septic sore throat have been traced directly to infected

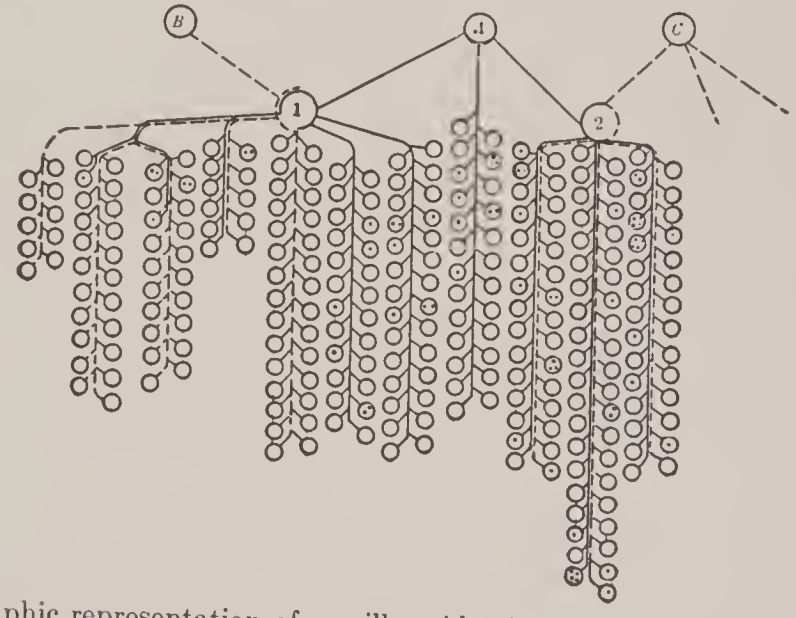

FIG. 2.—Graphic representation of a milk epidemic of scarlet fever. *A*, *B*, and *C* are milk producers. 1 and 2 are milk distributors. The circles represent households, the enclosed dots cases of scarlet fever. Upon farm *A* there was a case of scarlet fever. The diagram shows that milk from farm *A* gave rise to scarlet fever even when mixed with other milk. Reprinted from Conn's "Bacteria in Milk and Its Products." P. Blakiston's Son & Co., Phila., Pa.

milk. The outbreaks are sudden, and the patients usually have a common source of milk supply. Fortunately, except with septic sore throat, cases are usually of a relatively mild type. Outbreaks of septic sore throat have usually been extremely virulent, resulting in severe prostration and an abnormally high death rate. The tabulation of Kelley's investigation shows that the deaths were 6.6 per cent of the cases in the diseases studied. Where milk was the carrier of infection, deaths were only 3.2 per cent of the cases. Milk-borne scarlet fever

had a death rate only one-half as high as all scarlet fever cases. On the other hand, there was an average of $2\frac{1}{2}$ deaths per 100 cases of milk-borne septic sore throat, compared to 2 deaths per 100 general cases of the same disease. Capps and Miller (5) investigated an epidemic of septic sore throat occurring in Chicago in 1911. They estimate that fully 10,000 persons were afflicted and that 87 per cent of the cases investigated took milk from one dairy.

Foot-and-Mouth Disease.—The following extract from Farmers' Bulletin 666, U. S. Department of Agriculture, (6) describes the method of infection with foot-and-mouth disease, an ailment of cattle which, fortunately, is infrequently communicated to man in this country.

"Foot-and-mouth disease is primarily and principally a disease of cattle; secondarily and casually, a disease of man. It is transmissible to man through the eating or drinking of raw milk, buttermilk, butter, cheese, and whey from animals suffering from foot-and-mouth disease. It is also transmitted directly, though more rarely, from the salivary secretions or other infected material which may gain entrance through the mucous membrane of the mouth. It is doubtful whether the disease can be transmitted to man by cutaneous or subcutaneous inoculation, though it is probable that the infection may be communicated if the virus directly enters the blood through wounds of any kind. Children are not infrequently infected by drinking unboiled milk during the periods in which the disease is prevalent in the neighborhood, while persons in charge of diseased animals may become infected through contact with the diseased parts or by milking, slaughtering, or caring for the animals.

"Veterinarians who have had considerable experience with the disease among animals regard the human affection as by no means uncommon in countries where foot-and-mouth disease prevails, but the disturbance of health is usually too slight to come to the notice of the family physician.

"But few outbreaks of the disease have occurred in the United States, and therefore cases of its transmission to man in this country are quite rare."

Undulant Fever. Malta Fever.—The following statement is from Hasseltine : (16)

"For the purpose of this discussion the term 'undulant fever' includes Malta fever and all other febrile disturbances caused by infection with a member of the bacterial genus *Brucella*.

"Twenty-four years ago undulant fever made its debut into Amer-

ican medical circles when Craig reported the first case of Malta fever in the United States.

* * *

"In 1918 Evans called attention to the fact that the organism causing Malta fever was practically identical with that causing infectious abortion of cattle. This announcement caused numerous laboratory investigators to repeat the work of Miss Evans and, when it was confirmed, there was speculation as to infection of human beings with the organism of infectious abortion until Keefer (in 1924) reported a case of Malta fever which was proved by positive blood culture to be due to the *abortus* organism.

* * *

"As to the amount of undulant fever in the United States, we have no reliable statistics, as the disease is not reportable in some States, and has been reportable only a short time in others. Laboratory workers have conducted serological surveys by applying the agglutination test using *Br. abortus* as antigen, to all serums submitted for Wassermann or Widal tests. The results have been quite variable in different States, owing partly to a difference in the agglutination titer that each laboratory requires before a positive result is recorded, and partly to a true difference in prevalence. These results vary from 0.6 per cent to 7.5 per cent according to the titer considered necessary for a positive report.

"In a questionnaire sent to different State laboratories Hardy collected information up to January 1, 1929. In 1928, 40 States reported 560 positive results; in 1927, 18 States reported 194 positive; in 1926, 7 States reported 34 positive. These figures represent persons whose serum showed agglutinins for *Brucella melitensis* or *Brucella abortus*. An attempt to ascertain the number of clinical cases reported in the literature since January 1, 1927, has been only partially completed, but has revealed over 300 cases reported.

* * *

"We know comparatively little of the pathology of the infection in human beings. Whether the infection with the types of *Brucella abortus* differs in its pathology from that of *Brucella melitensis* is not yet known.

* * *

"At the present time it appears that there are at least three strains of the *Brucella* genus that may cause undulant fever. These are known as the caprine, bovine, and porcine strains. Huddleson has assigned to each a specific name, the caprine strain being *Brucella melitensis*, the bovine strain *Brucella bovis*, and the porcine strain *Brucella suis*.

* * *

"The fact that British soldiers and sailors seemed to get Malta fever from goat's milk has probably led us to believe that most undulant fever is contracted through milk. While a goodly proportion of cases in the United States have no other reasonable explanation, there are many cases, especially in rural districts, that may be due to contact with infected animals. For instance, a farmer may have infectious abortion present in his cows and he uses a portion of the milk produced on his place. There is a tendency to attribute such farmer's attack of undulant fever to infected milk. But the fact that in rural sections the fever attacks about five males to one female suggests that the men are more exposed to infection than the women. This is brought up not as an argument that the disease may not be milk-borne, but to emphasize the point that we should consider all possible sources of infection, particularly when two or more exist in connection with any individual case."

The U. S. Bureau of Animal Industry gives as its opinion that:

"We are, therefore, encouraged to believe that it is only when milk becomes infected with *Bact. abortus* possessed of an unusual kind or degree of virulence that it can cause undulant fever and that the usual type of the microorganism met with in milk is relatively harmless for man. Of course it is possible that milk containing an unusually large number of the microorganisms, even though of the usual type, such as from a single cow whose udder is grossly infected, may cause the disease, especially in highly susceptible persons.

"It appears, therefore, though *Bact. abortus* does at times cause undulant fever in man, that the number of cases reported bears a very small proportion to the number of people exposed through consuming raw infected milk and that a considerable number of reported cases have acquired the disease through contact with infected animals, especially swine."

The foregoing statements indicate very clearly that cows' milk may be a factor in the causation of undulant fever; but from present indications it is not wise to over-emphasize this until more evidence is available. There is no cause for undue alarm. On the other hand, every practicable step should be taken to eradicate abortion disease.

GASTRO-INTESTINAL DISORDERS

Certain gastro-intestinal disorders of young children have been ascribed to dirty milk. These disorders are commonly called "cholera infantum"; "diarrhea," or "summer complaint." It is an established fact that such diseases of infants are much more frequent in summer, when, because of hot weather, milk has a higher bacterial content. Undoubtedly much of the blame rests on sources other than milk. Lack of intelligent care, when the child's resistance is weakened by the summer's heat, has much to do with the question. Fly contamination of food, bottles, nipples, etc., also plays a part. Milk, however, is by no means blameless; there is a close association between milk of high bacterial content and infant morbidity and mortality; and when the purity of milk supplies is improved there is usually a reduction of infant mortality.

Several theories have been advanced to explain the relation of milk to diarrheal diseases of infants. Large numbers of miscellaneous bacteria, bacteria of the colon type, and specific but as yet unknown bacteria, have all been suspected; but, unfortunately, there is no reliable proof of any of these theories. Infants cannot readily be experimented upon, for obvious reasons, and experiments with other animals do not give sufficient data on this point for application to humans. Perhaps the most interesting observations are those reported by Park and Holt, (7) who, with a number of co-workers, conducted investigations in 1901 and 1902, observing over 600 infants in New York tenement houses and institutions. Different grades of milk were being fed to the infants at the time. None of the subjects were put on a diet of dirty milk; but some of those receiving such milk were allowed to continue it. First, a careful bacterial study of the milk was conducted, which resulted in the isolation of 239 varieties and 31 general classes of bacteria. Accompanying this was a study of bacteria from general sources. From results obtained, the investigators found that 11 types of organisms from grass and hay, 26 from manure, and 5 from feed, bore a close resemblance to bacteria from milk. Kittens were fed with cultures of 139 varieties of bacteria, but only one culture produced illness and death. The observers did not establish a relation between any specific variety of bacteria and the health of children.

The children observed were in the following age groups:
Under six months, 340.
Seven to twelve months, 265.
A little over twelve months, 47.
The general condition of the milk used was as follows:

Condensed milk—sweetened.

Store milk { 20,000,000 bacteria per cubic centimeter the first summer
3,000,000 " " the second summer
400,000 " " in winter

Bottled milk—500,000 bacteria per cubic centimeter.

Milk from Central Distributing Station { 2,000,000 bacteria per cubic centimeter before pasteurizing
500 " " after pasteurizing
5 " " " boiling

The following tables show the number of infants fed the different classes of milk; and also the results:

WINTER

Kind of Milk.	Did Well.	Did Fairly.	Did Badly.	Died.	Totals.
Store milk	47	6	2	0	55
Condensed milk	39	5	2	2	48
Good bottled milk	51	13	1	3	68
Milk from Central Distributing Station	35	20	4	0	59
Best bottled milk	5	0	1	0	6
Breast	7	1	0	1	9
Totals (excluding duplications)	156	41	8	6	211

SUMMER

Kind of Milk.	Did Well.	Did Fairly.	Did Badly.	Died.	Total.
Store milk	21	23	20	15	79
Condensed milk	22	20	14	14	70
Good bottled milk	37	23	29	9	98
Milk from Central Distributing Station	84	33	24	4	145
Best bottled milk	9	3	0	0	12
Breast	17	7	7	0	31
Totals (excluding duplications)	184	108	88	41	421

The authors note that in winter 93 per cent good results were obtained; while in summer only 69 per cent were favorable. Further-

more, there was, in the winter, only 1 death connected with disorders of the digestive tract. During the summer periods, 32 of the 41 deaths were caused by diarrheal diseases. Most of the cases showing bad results were from store milk of high bacterial count. The authors reach the general conclusion that milk containing over 1,000,000 bacteria per cubic centimeter is harmful to infants.

A very interesting relation between clean milk and gastro-intestinal disorders in older persons has been noted at the United States Naval

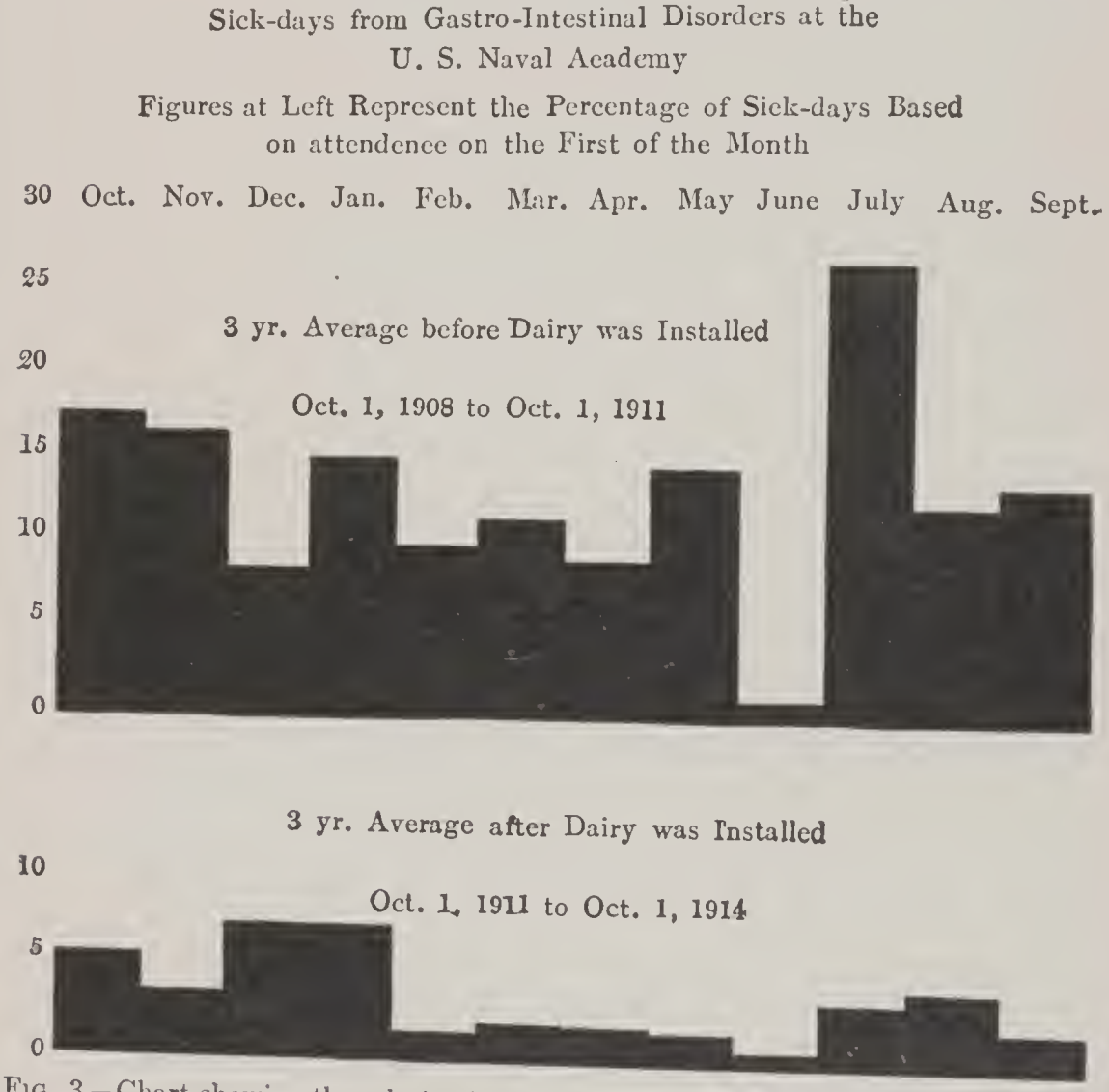
Sick-days from Gastro-Intestinal Disorders at the U. S. Naval Academy
Figures at Left Represent the Percentage of Sick-days Based on attendence on the First of the Month
30 Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept.
25
20
15
10
5
0
3 yr. Average before Dairy was Installed
Oct. 1, 1908 to Oct. 1, 1911
3 yr. Average after Dairy was Installed
10
5
0
Oct. 1, 1911 to Oct. 1, 1914

FIG. 3.—Chart showing the relation between a clean milk supply and sickness from gastro-intestinal disorders at the U. S. Naval Academy.

Academy, Annapolis, Md. (8) Previous to October, 1911, the Academy received its milk supply from scattered dairies. In the fall of 1910 an outbreak of typhoid occurred which was reported to have been carried by milk. The Academy authorities decided to establish a sanitary dairy under their own control; work on this dairy was immediately started, and milk from it was furnished the Academy in October, 1911. Fig. 3

shows the three-year average of sick days from gastro-intestinal disorders before and after the dairy was installed. It can be readily seen that such disorders were greatly diminished when a pure milk supply was secured. An even better showing has been made in later years. While milk may not have been wholly responsible for this improvement, presumptive evidence is strongly in favor of the benefit of clean milk.

SOURCES OF INFECTION

Milk is infected through three principal channels, namely,

1. Direct bovine infection.
2. Direct or semi-direct human infection.
3. Indirect infection.

In a relatively small proportion of cases, bovine infection, in tuberculosis, is due to a diseased udder. Schroeder has shown that the bacillus of tuberculosis is frequently excreted in the feces of diseased animals; under ordinary dairy practice, particles of manure may be splashed, sprayed or otherwise introduced into milk, thus infecting it with the bovine tuberculosis bacillus. It has already been stated that foot-and-mouth disease and, in the case of goats, Malta fever may pass directly from the animal into the milk.

Certain streptococcic infections of cows' udders have been suspected as the source of infection in human cases of scarlet fever and septic sore throat. Capps and Miller, (5) in their investigation of the Chicago outbreak of septic sore throat, found that, of the cows supplying milk to the dairy under suspicion, 4.6 per cent had mastitis, or infected udders. It is quite possible that a very careful study of dairy herds in general would reveal a similar percentage of like cases. At the present time there is not sufficient scientific proof at hand to warrant the statement that streptococcic udder infections of cows are responsible for specific diseases of man.

Direct human infection of the milk supply is well established. Milkers or milk-handlers suffering from mild or "walking" cases of infectious diseases are the chief cause. Bacteria or infectious material may be introduced into milk from their hands, either during milking or in handling milk utensils. In typhoid fever particularly has this been observed. Persons who have apparently recovered from this disease may harbor bacteria in their bodies for years. These bacteria are excreted in the urine, and contaminate the hands of the milker. Such people are called "carriers." Perhaps the most remarkable case was that noted by Bolduan and Noble (9) in New York, where a typhoid epidemic of several hundred cases was traced back through the country

shipping station to a certain dairyman who had been a typhoid carrier for forty-six years. Cumming (10) also reported an occurrence of typhoid among consumers of ice-cream which had been infected by a carrier.

Indirect human infection may come through persons who have been in contact with cases of an infectious disease and carry contagion from the patient to the milk. Harrington (11) reports a milk-borne scarlet fever epidemic around Boston, which caused 485 cases in five days among patrons of one dairy. The infection was traced to a dairyman whose daughter was sick with scarlet fever, and who had himself some light symptoms.

Other indirect means of infection are water supplies and flies. An examination (12) of the water supply on sixty dairy farms selected at random around the District of Columbia, showed that only 25 per cent were satisfactory from a sanitary standpoint. In Minnesota, seventy-nine water supplies were examined; twenty were good and fifty-nine polluted—practically the same percentage as in the District of Columbia report. Water supplies may be contaminated by surface drainage from privies, barnyards, hog-pens, etc., or by underground water from the same sources, when the earth strata permit Thompson (13) described typhoid fever resulting from the use of a well which had been infected from a privy. Geiger (14) also notes a typhoid epidemic traced to polluted water. The contamination of milk by water supplies usually occurs through the washing of dairy utensils which are not thereafter properly sterilized. There is also a possibility of cows wading in polluted water; in such cases bacteria may adhere to the udder and subsequently fall into the milk pail.

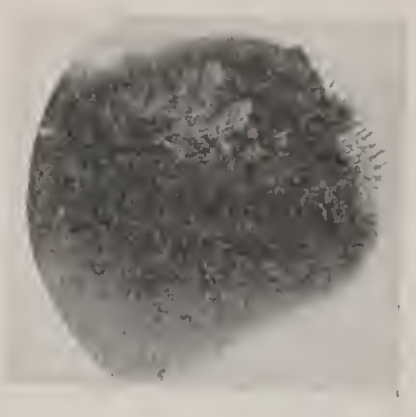

Fig. 4.—Photomicrograph of a hairy pad from fly's foot showing bacteria-laden dirt held in network of fine hairs. Photo by E. A. Shuster, Jr.

Flies may carry infectious material from unscreened privies to the stable or milk house. Fig. 4 shows one of the pads on a fly's foot which holds dirt and bacteria in the network of hairs.

Milk utensils and milk bottles, which have been in houses where infectious diseases exist, may also serve as contaminating agencies.

MINIMIZING DANGER OF MILK INFECTION

Careful inspection of dairy establishments, together with constant laboratory control, can reduce milk infection greatly. The tuberculin test for dairy cattle is reliable and accurate and practically eliminates bovine tubercular infection from milk. Where milk is sold for consumption in its raw state, every milk-handler on dairy farms and in city plants should undergo frequent and thorough medical examination. As such examination is not often possible in a general milk supply, pasteurization has been adopted very generally. Even in pasteurizing plants, however, employees should have medical examinations to prevent recontamination of the milk. So far as the authors know, there has never been an outbreak of infectious disease traced to properly pasteurized milk. In several epidemics due to raw milk, proper pasteurization of the supply under suspicion has resulted in a speedy subsidence of new cases and a disappearance of the epidemic. Pasteurization will be discussed at greater length in another chapter.

CERTIFIED MILK

In 1889 the Medical Society of New Jersey started a movement to encourage the production of a high-grade raw milk, especially suited

FIG. 5.—Dairy buildings suitable for the production of Certified Milk.

for infant feeding. This effort resulted in the establishment, in 1893, of the first dairy for the production of "certified milk." (15) At the present time there are about 178 certified dairies under the supervision of

approximately eighty-eight medical milk commissions. These commissions are usually selected by county medical societies, but sometimes this function is delegated to state or municipal boards of health.

In 1912 the American Association of Medical Milk Commissions adopted official methods and standards for the production and distribution of certified milk (amended June 24, 1930). These rules comprise sixty-eight regulations, covering health, housing, and feeding of cows; milking and caring for the milk; water supplies and toilets; health of employees; and bacteriological and chemical standards for the milk itself. In general, these regulations require: Tuberculin test and physical examination of cattle; medical inspection of employees; small top milking pails; sterilized utensils; prompt cooling to between 32 and 50° F.; bacterial counts below 10,000 per cubic centimeter; fat content averaging 4.0 per cent, with a minimum of 3.5 per cent; and freedom from coloring matter and preservatives.

REFERENCES

(1) Milk and Its Relation to the Public Health Hygienic Laboratory, Bul. 56, U. S. Treasury Dept.
(2) Supplement No. 62 to the Public Health Reports, U. S. Pub. Health Service. 1927.
(3) Schroeder, E. C., The Unsuspected but Dangerously Tuberculous Cow. B. A. I. Circ. 118, U. S. Dept. Agri.
(4) Park, Krumwiede, Anthony, Grund and Blackburn, The Relative Importance of the Bovine and Human Types of Tubercle Bacilli in the Different Forms of Human Tuberculosis. Collected Studies from the Research Laboratory of the Department of Health, City of New York, Vol. VI, 1911, p. 73.
(5) Jour. Am. Med. Assn., Vol. LVIII, No. 24, pp. 1848, 1852.
(6) Foot and Mouth Disease. Farmers' Bull. 666, U. S. Dept. Agri.
(7) Park and Holt, Archives of Pediatrics, Vol. XX, No. 12, p. 881.
(8) Kelly, Milk for Midshipmen. Separate No. 857, from Yearbook of the U. S. Dept. Agri., 1920.
(9) Jour. Am. Med. Assn., Vol. LVIII, No. 1, p. 7.
(10) Jour. Am. Med. Assn., Vol. LXVIII, No. 16, p. 1163.
(11) Harrington, N. Y. Med. Jour., Vol. LXXXV, 1907, p. 696.
(12) The Dissemination of Disease by Dairy Products and Methods for Prevention. B. A. I. Circular 153, U. S. Dept. Agri.
(13) Jour. Am. Med. Assn., Vol. LVIII, No. 13, p. 932.
(14) Jour. Am. Med. Assn., Vol. LXVIII, No. 13, p. 978.
(15) Kelly, Medical Milk Commissions and Certified Milk. Bull. 1, U. S. Dept. Agri.
(16) Pub. Health Repts. U. S. Pub. Health Service. Vol. XLIV, No. 28, July 12, 1929.
Kelley and Osborn, Further Evidence as to the Relative Importance of Milk Infection in the Transmission of Certain Communicable Diseases of Man. Am. Jour. of Public Health, Vol. X, No. 1.
Kelley, E. R., The Quantitative Relationship of Milk-Borne Infection in the Transmission of Human Communicable Diseases. Jour. Am. Med. Assn., Vol. LXVII, No. 27, p. 1997.
Diarrheas in Bottle-fed Infants. Medical Record, Vol. 80, No. 23, p. 1123.

Am. Jour. of Pub. Health, Vol. III, No. 5, p. 486.
Hallman and Anthony, Undulant Fever in Man and Abortion Disease in Cattle, Circ. Bull. 128, Mich. State Coll.
Boston Med. and Surg. Jour., Dec. 14, 1911, p. 899.
Jour. Am. Med. Assn., Vol. LVIII, No. 15, pp. 1109–1111.
Jour. Am. Med. Assn., Vol. LIX, No. 19, p. 1715.
Am. Jour. Pub. Health, Vol. IV, No. 6, p. 506.
Jour. Inf. Diseases, 17 (1915), No. 1, p. 69.
Med. Record, Vol. 88, No. 23, p. 945.
Jour. Inf. Diseases, Vol. 20, No. 1, p. 45.
Jour. Am. Med. Assn., May 5, 1917, p. 1305.
Am. Jour. Pub. Health, Jan., 1918, p. 40.
Idem., Jour. Med. Res., Vol. XXIII, No. 2, p. 205.
Infant's Milk Depots and Their Relation to Infant Mortality. N. Y. Assn. for Improving the Condition of the Poor.
McCleary, G. F., Infantile Mortality and Infants' Milk Depots.
Savage, W. G., Milk and the Public Health.
Rosenau, M. J., The Milk Question.
Why Health Departments are Interested in the Eradication of Bovine Tuberculosis. Paper by Dr. W. A. Evans before the Tuberculosis Eradication Conference. Chicago, Ill., Nov. 25, 26, 1921.
Ward, A. R., Pure Milk and the Public Health.

CHAPTER IV

CHEMISTRY AS APPLIED TO MARKET MILK

COMPOSITION

The chemical composition of normal cow's milk varies throughout a rather wide range. It is affected by a number of factors, which will later be discussed at some length. The following table shows the average analysis of milk, as compiled from the results reported by seven American and one English investigator:

Average Composition of Cow's Milk

Water	87.17	per cent	
Fat	3.74	"	Solids 12.83 per cent
Casein	2.87	"	
Albumen	.56	"	
Sugar	4.94	"	
Ash	.72	"	
Total	100.00	"	

The greatest variations reported by investigators in this country are as follows:

Constituent.	Minimum. Per Cent.	Maximum. Per Cent.
Water	82.0	90.0
Fat	2.3	7.8
Casein and albumen	2.5	4.8
Sugar	3.5	6.0
Ash	.6	.9

Besides these materials, there are present in milk certain other things, such as gases and enzymes.

PROPERTIES OF CONSTITUENTS

Milk-fat, or butter-fat, is a mixture of triglycerides of various fatty acids, and exists in milk in the form of small globules of varying size. Race (1) gives the size of fat globules as varying from .8 micron to 20 microns in diameter, with an average of 2.7 microns. Wing states (27) that fat globules vary in diameter from 1/1500 to 1/25000 inch. A single drop of milk contains over 100,000,000 fat globules. Milk from

Jersey and Guernsey cows contains larger fat globules than that from Holsteins or Ayrshires. Individual animals also differ in this respect, and generally the size of the fat globules diminishes as a cow advances in her lactation period.

Microphotographs of over 21,000 fat globules in 75 milk samples have been made. It was found that the mean diameter of 2,727 Jersey fat globules was 3.34 microns with a standard deviation of 1.33 microns; of 14,853 fat globules of Holstein milk 2.5 and 1.19 microns; and of 3,490 Ayrshire fat globules, 2.34 and 1.16 microns.

Race (1) gives the following properties of milk-fat:

Specific gravity	.9094–.9140
Refractive index at 35° C.	1.455-1.4586
Melting-point	28° C.–36° C.
Solidifying point	21° C.–27° 3.
Reichert-Wollny value	25–27
Iodine absorption	31–35
Caloric value	9.231 calories per gram

Two groups of fat are found in mixture in milk-fat. They are the volatile and non-volatile. The non-volatile fats are the "base" fats and comprise about four-fifths of the total fat volume. Chief among this group are olein and palmitin. The volatile fats play a large part in the production of both desirable and undesirable flavors of milk and milk products.

All of the fats are combinations of glycerin and acids; thus, olein is a combination of glycerin and oleic acid. Browne (2) gives the following percentages of fatty acids as found in milk:

Non-volatile:	Percentage.	*Volatile:*	Percentage.
Oleic	33.95	Butyric	6.23
Palmitic	40.51	Lauric	2.73
Myristic	10.44	Caproic	2.32
Stearic	1.91	Caprylic	.53
Dioxystearic	1.04	Capric	.34

In connection with these figures, it is well to remember that there has been some difference of opinion concerning this subject. For instance, at least two writers place lauric acid in the non-volatile group. Milk-fats are the chief constituents of butter.

The chief proteids of milk are the casein and albumen; in addition, traces of globulin and mucoid proteid are usually found, but are not in sufficient quantities to warrant further discussion.

Casein comprises about five-sixths of the nitrogenous constituents of milk. It is a phospho-protein which exists in milk as a salt. The free casein itself is insoluble in water and when pure is generally seen

as a white powder without flavor or odor. The casein in milk does not coagulate with heat, but when set free by acidification of the milk it is thrown out of its solution as the "acid curd." By the digestive action of rennet or pepsin, paracasein is formed, which, with the calcium of milk, forms a curd of the type found in cheese-making.

Albumen, the other protcid constituent, is also a white powder, without odor or flavor, but is found in solution in milk. Its properties differ somewhat from those of casein; it does not coagulate with acids or the ferments, such as rennin, but it does coagulate when heated above 158°–160° F.

Milk sugar, or lactose, is a whitish powder, which is found in solution in milk. Aside from its food value, its main importance is due to the fact that it is the source of lactic acid. At optimum temperatures (75°–95° F.), certain types of bacteria split milk sugar into dextrose and galactose, which are in turn changed into lactic acid. In fresh milk there is little or no lactic acid. When two-tenths of 1 per cent of acid has developed, milk is unsafe commercially for use in pasteurizing, condensing, etc. At about three-tenths of 1 per cent, a sour taste becomes noticeable, and the development of acid goes on until nearly 1 per cent of acid is reached, when the production of acid ceases, because of the inhibitory effect of the acid on the causative bacteria.

Ash, or mineral matter, is present in milk in small quantities. It represents the residue left when milk solids are incinerated, and is often spoken of as the "salts" of milk. Most of the salts are held in solution in milk, but some are held in fine suspension. The ash comprises the inorganic constituents of milk, but is very largely in combination with organic bodies. Richmond gives the following analysis of ash in cow's milk:

Cow's Milk. Analysis of Ash (Richmond) (10)

	Per Cent.
Lime	20.27
Magnesia	2.80
Potash	28.71
Soda	6.67
Phosphoric acid	29.33
Chlorine	14.00
Carbon dioxide	.97
Sulphuric acid	trace
Ferric oxide	.40
Total	103.15
Less oxygen = Cl	3.15
	100.00

Cow's milk contains a larger percentage of nearly all the minerals than does the milk of the human mother. Only one constituent, iron, is an exception. Lane-Claypon (3) states that "the iron content of human milk is from two to three times as great as that of cow's milk."[1]

OTHER SUBSTANCES IN MILK

Milk contains several other substances besides the chemical constituents already named. Among these are lecithin, gases, enzymes and bacteria.

Lecithin is a nitrogenous, ether-soluble substance found only in minute quantities and possessing little or no interest to the student of milk.

Gases are absorbed from the air during milking, the chief ones being oxygen, nitrogen and carbon dioxide. When milk stands for a time, the oxygen diminishes and carbon dioxide increases.

Enzymes have never been separated out in a pure condition, and therefore very little is known about them. We do, however, know something of the work they do and classify them accordingly. They are very wonderful substances. Minute quantities can produce considerable chemical change in milk without apparently suffering any change themselves.

Examples of enzymic action may be seen in the coagulation of milk by rennet. The chief enzymes found in milk are amylase, galactase, catalase, peroxidase, reductase, lipase, and lactokinase.

RELATION OF MILK SOLIDS TO THEIR CONSTITUENTS

Lythgoe (4) records interesting observations after analyzing large numbers of samples of milk of known purity.

Fat to Solids.—He reports the percentage of fat in the solids of Jersey milk as 38, and in Holstein milk as 27. The highest rate found was 47.4 per cent in a sample of Jersey milk, and the lowest 25 per cent in a sample from a Holstein.

Solids and Protein.—Protein comprises about 25 per cent of the solids and is fairly constant in this relation.

Solids and Ash.—The ash being nearly constant, its percentage relation to the solids increases as they diminish. In Jersey milk the ash is 4.9 per cent of the solids, while in Holstein milk it is 5.7 per cent.

Solids and Sugar.—In Jersey milk the sugar is about 30 per cent of the solids, while in Holstein milk it is 40 per cent.

Protein-Fat Ratio.—Lythgoe ranges his ratios from 1 : 0.61 to 1 : 0.86, while he reports Van Slyke's range as 1 : 0.64 to 1 : 0.87.

[1] Reprinted by permission of Longmans, Green & Co., N. Y.

Lythgoe says, " there seem to be three groups of cows according to the protein-fat ratio, those of the Jersey type with the protein-fat ratio below 0.7, those of the Holstein type with the protein-fat ratio above 0.85, and the balance of the breeds with a protein-fat ratio about 0.8." [1]

RELATION OF FAT TO SOLIDS-NOT-FAT AND TOTAL SOLIDS

In comparing normal milks of different richness, it is apparent that as the percentage of fat increases the solids-not-fat also increase, but

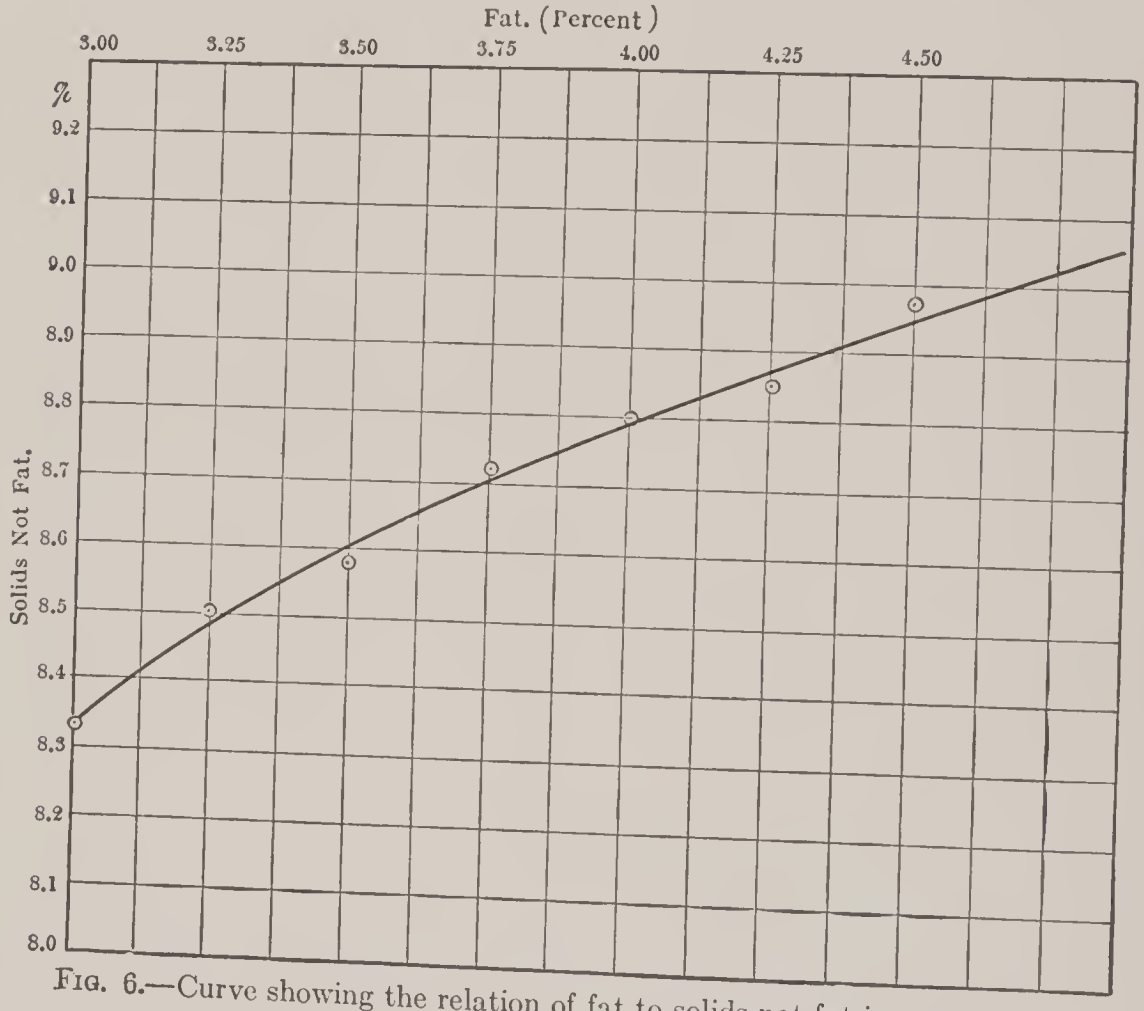

FIG. 6.—Curve showing the relation of fat to solids-not-fat in normal milk.

not in the same ratio. For example, an increase of 1 per cent in fat is accompanied by an increase of less than 1 per cent in the solids-not-fat. Various investigators have reported on the relation of fat to solids, but these reports have varied considerably. The following original chart has been prepared to summarize the findings of those who report large numbers of analyses. It includes data from Publow and Troy, (5) Lythgoe (4) and Brown and Ekroth's (6) compilation, as well as some 1710 analyses supplied the author by Borden's Condensed Milk Com-

[1] Reprinted by permission of Jour. of Indust. and Eng. Chem.

pany. Altogether the figures represent analysis of over 250,000 samples. The curve in Fig. 6 was plotted from these data and is believed to represent very accurately the relation of fat to solids-not-fat in average milk.

According to this chart, the following relations are representative·

TABLE 9

Relation of Fat to Other Solids in Milk

Fat.	Solids-not-fat.	Solids.	Ratio Fat to Solids-not-fat.
3.0	8.33	11.33	1 : 2.77
3.1	8.40	11.50	1 : 2.71
3.2	8.46	11.66	1 : 2.64
3.3	8.52	11.82	1 : 2.58
3.4	8.55	11.95	1 : 2.52
3.5	8.60	12.10	1 : 2.46
3.6	8.65	12.25	1 : 2.40
3.7	8.69	12.39	1 : 2.35
3.8	8.72	12.52	1 : 2.30
3.9	8.76	12.66	1 : 2.25
4.0	8.79	12.79	1 : 2.20
4.1	8.82	12.92	1 : 2.15
4.2	8.86	13.06	1 : 2.11
4.3	8.89	13.19	1 : 2.07
4.4	8.92	13.32	1 : 2.03
4.5	8.95	13.45	1 : 1.99
4.6	8.98	13.58	1 : 1.95
4.7	9.01	13.71	1 : 1.92
4.8	9.04	13.84	1 : 1.88
4.9	9.07	13.97	1 : 1.85
5.0	9.10	14.10	1 : 1.82

It will be noted that, in milks rich in fat, the ratio of fat to solids-not-fat is higher than in poor milk. Indeed, this ratio seems to rise in mathematical sequence as the fat increases. From Table 9 it will be seen that the "fat to solids-not-fat ratio" increases approximately as follows: In milk having fat from 3.0 to 3.6 per cent, .06 for every .1 per cent fat; 3.6 to 4.1 per cent fat, .05 for each .1 per cent fat; 4.1 to 4.6 per cent fat, .04 for each .1 per cent fat, and 4.6 to 5 per cent fat, .03 for each .1 per cent fat.

RATIO OF COMPONENTS IN SOLIDS-NOT-FAT

W. G. Savage (7) quotes Vieth as giving the following ratio of the components in the solids-not-fat:

Sugar	13
Protein	9
Ash	2

FACTORS INFLUENCING CHEMICAL COMPOSITION OF MILK

Many factors influence the chemical composition of milk. Some of them affect the relation of the various solids to each other, while others influence the character of the solids, causing changes in the size and hardness of the fat globules, etc. There follows a brief discussion of factors in the first group only, which are the most important ones in a discussion of market milk.

Breed.—Cattle of different breeds produce milks which differ in composition. For instance, the milk of the Channel Island breeds is characterized by relatively high percentages of fat and solids.

Snyder (8) gives the following as the average composition of milk from the leading breeds of dairy cattle:

Breed.	Total Solids.	Fat.	Casein.	Sugar.	Ash.
Holstein-Friesian	12.39	3.46	3.39	4.84	.74
Ayrshire	13.06	3.57	3.43	5.33	.70
Jersey	15.40	5.61	3.91	5.15	.74
Guernsey	14.60	5.12	3.61	5.11	.75

Other authorities give varying analyses, some higher, some lower. An examination of available data given by leading chemists and by the State Experiment Stations in this country gives the following average for fat and solids:

Breed.	Fat.	Solids-not-fat.	Total Solids.
Jersey	5.23	9.46	14.69
Guernsey	4.95	9.43	14.38
Ayrshire	3.67	9.03	12.70
Holstein	3.35	8.59	11.94
Shorthorn	3.78	9.04	12.82
*Duteh Belted	3.40	8.91	12.31
*Brown Swiss	3.62	8.99	12.61

* Reports from only one source.

Volume of Milk.—It may be said in general that cows producing large quantities of milk show a lower percentage of fat and solids. This holds true as regards breeds and individuals within the breeds.

Stage of Lactation.—Soon after the lactation period begins, the percentage of fat and other solids decreases slightly, until somewhere between the sixth and ninth months when it increases until the end of lactation. At the end of the lactation period, the fat, protein, ash and total solids are higher than at the beginning; but the sugar is lower, according to at least one investigator. Tables 10 and 11 show results obtained in two investigations:

TABLE 10

AVERAGE MILK COMPOSITION BY FOUR-WEEK PERIODS. ALL BREEDS

(Eckles and Shaw) (9)

Period.	1	2	3	4	5	6	7
Total protein	3.25	3.06	3.06	3.13	3.25	3.25	3.32
Fat	4.00	3.85	3.79	3.77	3.82	3.79	3.83
Sugar	4.87	4.84	4.94	4.82	4.80	4.75	4.88
Total solids	12.74	12.26	12.29	12.24	12.35	12.50	12.61

Period.	8	9	10	11	12	13	14
Total protein	3.32	3.57	3.83	3.89	4.08	4.34	
Fat	3.85	3.97	4.11	4.22	4.54	4.66	5.08
Sugar	4.83	4.62	4.55	4.74	4.91	4.50	5.01
Total solids	12.70	12.78	13.16	13.46	14.04	14.23	15.29

TABLE 11

AVERAGE COMPOSITION BY LACTATION PERIODS

(Lythgoe) (4)

Period.	1 Month.	2–5 Months.	6–9 Months.	10–15 Months.	Average.
Solids	12.70	12.76	13.03	13.15	12.89
Fat	3.98	3.97	4.14	4.22	4.06
Protein	2.93	3.19	3.43	3.43	3.29
Ash	.73	.74	.75	.76	.75
Sugar	4.90	4.86	4.71	4.75	4.81

In the constituents themselves, the most marked phenomenon is the change in the size of the fat globules. Eckles and Shaw state that the fat globules are very large immediately after calving. The size declines sharply during the first six weeks and then remains fairly constant for five or six months. After this the decline is much more rapid to the end of the lactation period. This explains the difficulty in raising cream or churning, often met with in milk of cows far advanced in lactation.

Colostrum.—The foregoing discussion of changes in milk during the period of lactation does not indicate a condition which exists at calving time and immediately thereafter. When the calf is dropped, the cow gives, for a certain period, a substance called "colostrum," or "beastings," which is especially suited to the new-born animal. It contains a large amount of solids and is laxative in its effect. In normal milk, albumen is found in smaller quantity than any of the other nutritive elements, but in colostrum it is the chief solid. In colostrum, the sugar is lower and the mineral constituents higher than in normal milk. After parturition, the milk gradually returns to normal condition, which is reached in two to ten days. The time varies with different individuals.

TABLE 12

ANALYSES OF COLOSTRUM

(Eugling)

	Immediately After Calving.	10 Hours.	24 Hours.	48 Hours.	72 Hours.
Specific gravity	1.068	1.046	1.043	1.042	1.035
Total solids	26.83	21.23	19.37	14.19	13.36
Casein	2.65	4.28	4.50	3.25	3.33
Albumen	16.56	9.32	6.25	2.31	1.03
Fat	3.53	4.66	4.75	4.21	4.08
Sugar	3.00	1.42	2.85	3.46	4.10
Ash	1.18	1.55	1.02	.96	.82

Influence of Feeds and Feeding.—*Overfeeding.*—Eckles and Palmer (11) determined by their experiments that overfeeding a dairy cow did not exert an influence toward abnormality in the composition of milk or the physical and chemical constants of milk-fat. On the contrary, it tended to correct abnormalities and delay changes due to advancing lactation.

Underfeeding.—The same authorities (12) found that underfeeding dairy cows generally resulted in a marked increase in both the yield and percentage of fat and in some cases in a decrease in the percentage of total protein, casein and ash. The lactose, or milk sugar, was not affected to any appreciable degree. The effect of underfeeding on the milk-fat was a marked reduction in the saponification value and Reichert-Meissl number and an increase in the iodine-absorption value. The authors state that other unknown factors probably exert some influence on these changes.

Change from Underfeeding to Liberal Feeding.—Wing took seven cows that had been underfed and gave them a liberal feed. He succeeded in increasing the fat percentage .25, an increase of 6 per cent over the original test.

Quality of Feed.—Numerous attempts have been made to increase the percentage of single constituents of cow's milk by feeding. So far no results have been obtained which indicate that any considerable permanent changes can be made by any method of feeding. Fat being the most valuable constituent of milk, most of the effort has been directed toward its increase. Wing fed cows relatively large amounts of suet, without perceptibly raising the percentage of fat in the milk.

It has often been claimed that watery feeds would lower the fat percentage, but, except in one instance, no scientific proof of this has been offered. Green rye and pasture grass have been said to influence low tests, but this has not been substantiated. Turner, Shaw and others found that very watery rations, comprising turnips, wet beet pulp and green crimson clover, had no effect on the percentage of fat or other constituents in milk. Furthermore, varying amounts of drinking water supplied to cows failed to affect the chemical composition of their milk. (13)

The single noteworthy exception along this line is found in the experiments of Woodward, Turner and Griffith. (14) In this work, varying amounts of prickly pear were fed to dairy cows. The prickly pears had an average water content of 91.3 per cent and were fed in amounts up to 150 pounds per cow per day. Heavy feeding of this substance increased the quantity of milk, but decreased the yield and percentage of fat. The larger the amount of prickly pear fed, the greater was the reduction in the fat percentage of the milk. During the first year of the experiment, cows which were fed hay as a roughage had an average test of 4.53 per cent fat; when a medium amount of prickly pear was fed, the test was 4.31 per cent; and when pears were fed heavily, the fat test was 3.92 per cent. Even greater differences were noted in the second and third years when other roughages replaced the hay.

Fatness at Time of Parturition.—Eckles reports that the percentage of fat in milk is influenced to a marked extent, for the first twenty or thirty days, by the fatness of the cow at parturition. This effect may continue to be exerted for as long a time as three months. Underfeeding after parturition seems necessary in order to obtain an abnormal fat percentage.

Variations in Individual Cows.—Different animals, even within the same breed, vary considerably in the chemical composition of their milk. Indeed, variations between individuals of the same breed are often greater than the differences between breeds. In addition to this, individual cows will vary the composition of their milk even under normal conditions. Eckles and Shaw (15) made a thorough study of seven cows to determine individual variations. The following results were obtained:

Protein.—The greatest variation in one cow was from 3.19 per cent to 2.55 per cent, or a variation of .64. No sample varied more than .3 from the average for the animal, and 90 per cent of the samples varied less than .2 from the average.

Sugar.—The greatest individual variation was from 5.46 per cent to 4.54, or a variation of .92. Ninety per cent of the samples varied less than .2 from the average.

Fat.—The greatest individual variation was from 4.15 per cent to 1.67 per cent, or a variation of 2.48. Only 56 per cent of the samples were within .3 of the average and 4.6 per cent varied more than .9 from the average.

These results show that while there are slight variations in the protein and sugar of the milk of individual cows, by far the greatest variation is in the fat.

Morning's and Evening's Milking.—When the periods between milkings are even, the morning's milk seems to have a slightly higher percentage of fat and sugar than the evening's milk. Eckles and Shaw give the following results of tests on five cows milked twelve hours apart:

Morning's and Evening's Milk

Time Drawn.	Protein. Per Cent.	Sugar. Per Cent.	Fat. Per Cent.
A.M.	3.346	5.102	4.096
P.M.	3.334	4.984	3.732

In this experiment all five cows gave a lower sugar percentage in the evening's milk, and 4 out of the 5 a lower fat percentage in the evening. These results are borne out by South Australian investigators, (16) who report a fat test .18 per cent higher in the morning's milk than in the evening's.

Eckles and Shaw state that animals milked three or four times daily showed greater variations in fat, but no appreciable variations in the other constituents. The highest fat percentage was found in milk drawn near the middle of the day.

Periods between Milkings.—When periods between milkings are unequal, it is nearly always true that a higher fat percentage is found in milk drawn after the short period. The South Australian source already quoted states that when the cows were milked at 6. A.M. and 3:30 P.M. the evening milk contained 1.09 per cent more fat than the morning's milk.

Influence of Season.—Averages of many analyses seem to show that the fat and solids of milk are lowest in the late spring and early summer months. This may be partially due to the fact that, throughout the country, large numbers of cows freshen in the spring, because dairymen prefer to produce the bulk of their milk when pasture is available.

Richmond (10) places the lowest fat percentage in May and June and the highest in October and November. He finds the lowest total solids in April, May, June and July and the highest in October and November. Lythgoe finds somewhat similar variations, but it will be noticed that the variation in fat in individual cows is much less than in herds, thus supporting the contention that spring freshening has a downward effect on herd tests.

TABLE 13

ANALYSIS OF MILK BY SEASONS

(Lythgoe) (4)

Season	Solids. Per Cent.		Fat. Per Cent.		Protein. Per Cent.		Ash. Per Cent.		Sugar. Per Cent.	
	Herd.	Individuals.	Herd.	Individuals.	Herd.	Individuals.	Herd.	Individuals.	Herd.	Individuals.
Winter (Dec.–Feb.)	13.23	13.16	4.20	4.24	3.41	3.39	.76	.75	4.88	4.80
Spring (Mar.–May)	12.87	12.72	4.14	4.00	3.13	3.16	.73	.75	4.92	4.78
Summer (June–Aug.)	12.39	12.46	3.73	3.97	3.15	3.18	.75	.77	4.71	4.55
Fall (Sept.–Nov.)	12.85	12.79	3.94	3.97	3.37	3.28	.74	.73	4.80	4.84

Age of Cow.—Apparently the only influence of the age of the cow on the composition of her milk is that the fat percentage is a trifle higher in young cows. Eckles and Palmer (17) state that Jerseys have the highest percentage of fat in one of the first three lactation periods—usually the second or third; Holsteins almost invariably show the highest fat in the first lactation period; and Ayrshires most often in the first. They further declare that the age of the cow produces no abnormalities of milk composition, neither does it affect the physical nor chemical constants of milk-fat. In their observations, one cow in her nineteenth year in test was farrow and had been in milk 864 days. Butter made from a nineteen-year-old cow was good and kept well.

Stage of Milking.—It is well known that the last milk drawn from a cow, called the "strippings," is richer in fat than previous portions. Van Slyke gives the following result as the average from three cows:

Part of Milking.	Fat Per Cent.
First drawn	1.37
Second drawn	3.02
Third drawn	4.82
Fourth or strippings	8.73

Eckles and Shaw made detailed analyses with the following results:

Part of Milking.	Protein. Per Cent.	Sugar. Per Cent.	Fat. Per Cent.	Ash. Per Cent.	Solids-not-fat. Per Cent.	Total Solids. Per Cent.	Relative Size of Fat Globules.
"Fore" milk	3.58	5.30	1.87	.75	8.80	10.67	139
Strippings	3.38	5.33	6.28	.70	8.58	14.86	215

This shows that the milk serum remains practically constant during milking, the only marked change being in the fat.

Disease.—Certain diseases, especially those of the udder, give rise to chemical and physical changes in the milk secreted. Some writers have noted that, in general, diseases have a tendency to decrease the percentage of sugar and protein in milk. Other observers state that there is a decrease in lactose but an increase in protein. From available data it does not seem likely that general diseases have any definite effect upon the composition of milk. Such diseases, however, often cause fluctuations in one or more of the milk constituents, but these fluctuations are not uniform.

On the other hand, diseases of the udder have a marked effect on the milk. For example, in mammitis the milk becomes watery, light

brown, or yellow in color, and contains slimy clots. With this change in physical condition come marked chemical and bacterial changes. Udder diseases are generally characterized by a milk low in fat, sugar and total solids, but high in protein and ash.

TABLE 14

EFFECT OF DISEASE ON THE COMPOSITION OF MILK

(Schaffer and Bondzynski)

Disease.	Total Solids.	Fat.	Lactose.	Protein.	Ash.	Ratios.	
						Protein Fat.	Lactose Protein.
Non-infectious garget.....	7.17	.82	.53	4.01	.79	4.89	.13
Yellow garget.....	10.66	1.99	1.84	6.00	.83	3.01	.31
Parenchymatous mastitis..	9.74	2.16	1.01	4.21	.99	1.99	.24
Normal milk.....	12.83	3.74	4.94	3.43	.72	.91	1.44

Period of Heat.—There seem to be no marked changes in the milk during the period while cows are in heat. Doane (18) studied five cows at the Maryland station and found nothing noteworthy, though two of the animals gave a slight rise in fat the second and third days. Other observers have reported marked changes in individual cows, usually a decrease of fat and an increase of protein.

Drouth.—Van Slyke (19) notes a decrease in casein and in the casein-fat ratio during periods of drouth. His figures are as follows:

EFFECT OF DROUTH ON MILK COMPOSITION

(Van Slyke)

Month.	Fat. Per Cent.	Casein. Per Cent.	Pound Casein for One Pound of Fat.
May.....	3.58	2.40	.67
June.....	3.59	2.33	.65
July.....	3.71	2.20	.59
August.....	4.04	2.26	.56
September.....	3.97	2.47	.62
October.....	4.20	2.69	.64

SPECIFIC GRAVITY AND WEIGHT

The specific gravity of milk is the weight of a given amount compared to that of an equal volume of water at the same temperature. For example, milk having a specific gravity of 1.032 weighs 1.032 times as much as the same volume of water. Richmond (10) states that milk from individual cows may be found with specific gravities ranging from 1.0135 to 1.0397, but the range in mixed milk of herds is between 1.030 to 1.034, with an average of 1.0322. The authors of this book believe that these limits are too narrow and are inclined to the range given by Race, which is 1.0264 to 1.037 at 60° F. Skim milk has a specific gravity of about 1.037 or 1.038 at 60° F.

The specific gravity of milk is influenced by the temperature of the milk and its composition, being raised when the temperature is lowered and vice versa. Thus, milk having a specific gravity of 1.032 at 68° F. would have a specific gravity of about 1.0328 at 60° F. Specific gravities are always taken at 60° F. or reduced to that basis before being recorded.

The specific gravity is increased by the solids-not-fat and is decreased by the fat. This is because the solids-not-fat are relatively heavy, having a specific gravity of about 1.5, while the fat is lighter, having a specific gravity near .93. The specific gravity of the total solids varies from about 1.25 to 1.34, with an average near 1.30. Murray (20) states that the specific gravity of milk is increased 4° of the lactometer by each 1 per cent of solids-not-fat, and lowered .8 of a lactometer degree by each 1 per cent of fat. He gives the following formula:[1]

$$G = 4N - .8F,$$

G = lactometer degrees;
N = solids-not-fat;
F = fat.

Then, a milk containing 4 per cent fat and 8.75 per cent solids-not-fat would give

$$G = (4 \times 8.75) - (.8 \times 4) = 31.8.$$

$G = 31.8$, or the specific gravity would be 1.0318.

In normal milk ranging from about 3 to 6 per cent fat, the influence of the solids-not-fat is greater than that of the fat, so that the specific gravity increases as the per cent of fat increases. Above 6 per cent, an

[1] Reprinted by permission of Longmans, Green & Co., N. Y.

increase of fat is usually secured by adding cream, which reduces the specific gravity.

When milk is first drawn it contains air bubbles. In about one hour these are dissipated, and the specific gravity is raised. Then the specific gravity rises again, this rising being known as "Recknagel's phenomenon."

The weight of milk is obtained by multiplying its specific gravity by the weight of an equal volume of water at the same temperature. For example:

8.32823 pounds = weight of 1 gallon of water at 60° F.
1.032 = specific gravity of milk

1665646
2498469
8328230

8.59473336 = weight of 1 gallon of milk at 60° F.

The following table shows the approximate weights of milk, cream and skim milk at 60° F.:

TABLE 15

WEIGHT OF 1 GALLON AT 60° F.

Substance.	Specific Gravity.	Weight of One Gallon. Pounds.
Water	1.0000	8.3282
Skim milk	1.0378	8.6430
Milk (3–6 per cent fat)	1.0322	8.5964
Cream, 18 per cent	1.0158	8.4598
" 20 "	1.0138	8.4432
" 22 "	1.0118	8.4198
" 25 "	1.0088	8.3949
" 30 "	1.0048	8.3682
" 35 "	.9998	8.3266
" 40 "	.9958	8.2933

REFRACTIVE INDEX

The refractive index is well described by Richmond, (10) who says, "When light passes from one medium to another it only passes in a straight line when it falls perpendicular to the surface separating the two

media. If it passes through at an angle to the surface, it is bent or refracted, and the ratio between the angle made by the path of the ray with the perpendicular to the surface in the first medium and the angle made by the path in the second medium with the perpendicular is a constant; the ratio of the sines of the two angles is known as the **index of refraction.**"

The refractive index is measured with an instrument called a " refractometer," which is useful in detecting adulterated, especially watered, milk.

SPECIFIC HEAT OF MILK

Hammer and Johnson (21) define specific heat as follows: " The ratio between the number of calories required to raise a given weight of a substance through a given temperature interval and the number of calories required to raise the same weight of the standard substance through the same temperature interval is called the **specific heat** of the substance."

The specific heat of a substance depends on its chemical nature and physical state. Water is usually taken as the standard, and its specific heat is expressed as 1. Table 16 is taken from the work of Hammer and Johnson. Their figures agree very closely with these given by Bowen. (22)

TABLE 16

SPECIFIC HEAT AT VARIOUS TEMPERATURES. (Hammer and Johnson)

Substance.	At 0° C.	At 15° C.	At 40° C.	At 60° C.
Whey	.978	.976	.974	.972
Skim milk	.940	.943	.952	.963
Whole milk	.920	.938	.930	.918
15 per cent cream	.750	.923	.899	.900
20 " " "	.723	.940	.880	.886
30 " " "	.673	.983	.852	.860
45 " " "	.606	1.016	.787	.793
60 " " "	.560	1.053	.721	.737
Butter	.512	.527	.556	.580
Butter-fat	.445	.467	.500	.530

Milk, having a lower specific heat than water, requires less heat to raise its temperature. Cream requires even less heat than milk. Conversely, it takes less refrigeration to cool milk than to cool a like amount of water, and less to cool cream than milk.

FREEZING POINT

The freezing point of milk is lower than that of water, or, in other words, it takes more cold to freeze milk than it does to freeze water. The freezing point depends on the composition but is fairly constant at $-0.55°$ C. Milk low in solids freezes at a temperature nearer the freezing point of water and vice versa.

The constancy of the freezing point is used for the detection of watered milk, by means of an instrument known as the " Cryoscope." With this apparatus the freezing point of a given sample of milk is determined and the amount of added water is estimated by the deviation from the normal.

COHESION AND VISCOSITY

When milk cools it becomes denser and adheres more closely to materials with which it comes in contact. Cold milk foams more readily, and the foam lasts longer. Milk also increases in viscosity after being drawn from the cow. This stickiness, or adhesive quality, is due, according to Babcock and Russell, (23) to the sugar, ash, etc., which are in solution in the milk serum, and to the physical state of the fat, casein and insoluble phosphate. These writers state that nitrogenous matter has about three times the influence of sugar upon the consistency of normal milk. The influence of the fat is mechanical and is due to the aggregation of the fat globules into clumps.

Bowen declares that, (22)

At 86° F. the viscosity of milk is 1.7 times as great as water
At 32° F. " " " 2.4 " " "
At 32° F. " " " 2.6 " " as that of milk at 86° F.

The viscosity of milk is influenced largely by the following factors:

1. Temperature.
2. Size and grouping of fat clumps.
3. Effect of acid on the casein.
4. Proportion of solids.

Changes in viscosity in milk and cream are commonly seen in dairy practice. Cold cream pours slowly and sticks to the can; if it is warmed it loses much of its viscosity.

The centrifugal force used in separating cream breaks apart the clusters of fat globules and diminishes the consistency of the cream to a marked degree. When milk sours, the action of acid precipitates casein

in tiny clots and increases its consistency greatly. It becomes thick and "creamy." The heating of milk and cream during pasteurization breaks up the fat clumps to a certain extent and thus decreases viscosity.

Pasteurized cream appears thinner than raw cream, and separated cream has less body than gravity cream of the same fat percentage.

COEFFICIENT OF EXPANSION

Milk expands with heat and contracts with cold. Therefore, a quantity of milk which has a given volume at a certain temperature will expand and occupy a greater space if it is heated. Conversely it will occupy less space if it is cooled. This change in volume is expressed as the "coefficient of expansion." Table 17 shows the volume of milk and cream at various temperatures compared with a unit volume (1.0000) at 68° F.

TABLE 17

VOLUME OF MILK AND CREAM AT VARIOUS TEMPERATURES OCCUPIED BY UNIT VOLUME AT 68° F.

(Bowen) (22)

Fat. Per Cent.	50° F.	60° F.	70° F.	80° F.	90° F.
4	.9975	.9985	1.0000	1.0020	1.0040
20	.9930	.9975	1.0005	1.0035	1.0070
30	.9915	.9965	1.0010	1.0050	1.0095
40	.9890	.9950	1.0010	1.0065	1.0115

COLOR

Milk contains certain substances which give it color, the yellow color of butter-fat being the most noticeable. This yellow color is derived from two chief classes of yellow pigments found in plants—carotins and xanthophylls. According to Palmer and Eckles, (24) carotin is the main source of pigment. It is taken into the body with vegetation eaten by the animal and is subsequently secreted in the fat. When feeds lacking these pigments are fed, as in winter, the fat loses much of its color. Fresh green grass is rich in carotin, hence the yellow color of milk and butter while cows are on pasture. The same authorities also found that while there are breed variations as regards the normal color of butter-fat, all milks are subject to the same variations when pigments are fed or withheld. For a short time after parturition, cows give milk having nigh-colored fat.

Richmond (10) states that the whitish color of milk serum is due to interferences with the passage of light, by the casein in pseudo-solution.

DRUGS AND FOREIGN SUBSTANCES

It has been noted that certain drugs and medicines, when fed to cows, pass through the body and are found in the milk. Frohner (25) reports that camphor, turpentine, camomile, aloe, arsenic, lead and tartar emetic may be transmitted to milk, sometimes in poisonous quantities. Mercury and copper may also be present in milk in sufficiently large quantities to endanger health. Baum (25) corroborates these findings and adds phenol, iodine, morphine, belladonna and strychnine to the list of drugs which may be transmitted in milk. Human mothers who use certain drugs transmit, in their milk, toxic doses of the drug used, and infants nursing them often have the typical symptoms and reactions of drug addicts.

CELLS

Cells or portions of cells are always found, even in normal cow's milk. Some of these cells are dead or dying epithelial cells from the gland tissue, others are leucocytes, or white blood corpuscles. Epithelial cells are discharged because they have broken down in the process of milk secretion, or because of certain diseased conditions of the gland. The mode by which blood corpuscles enter the milk stream has never been thoroughly proved.

Writers differ as to the exact classification and significance of cells in milk. It is generally conceded that the greater part of them are truly leucocytes, while a small proportion are epithelial cells. This statement is borne out by the observations of Breed, (26) while Race (1) states that in pathological conditions of the udder most of the cells are leucocytes.

The largest number of cells are found in colostrum. During the period of lactation they decrease, but they increase toward the close of the period and sometimes become as abundant as in the colostrum. Breed (26) states that there are marked daily variations in the cells discharged by individual cows, and that the four quarters of the same udder may vary as greatly as different udders. The reasons for these variations are not known.

In normal cows the variation in the cell count is tremendous. Lane-Claypon quotes (3) Russel and Hoffman as giving a variation from 4,000 to 1,000,000 per cubic centimeter. Savage (7) states it as from 50,000 to over 1,000,000 per cubic centimeter and observes that, in pathological conditions of the udder, cell counts as high as 200,000,000 to 300,000,000 per cubic centimeter have been obtained.

Breed (26) examined the milk of 122 cows and reported as follows:

No. Animals.	Cells per c.c.
59	Under 50,000
36	50,000 to 1,000,000
27	Over 1,000,000
Average	868,000

The significance of cells in milk, from a public health standpoint, is still at issue, but Race (1) declares that mixed milk containing over 1,000,000 cells per cubic centimeter should be regarded with suspicion, the assumption being that udder diseases may be present.

REFERENCES

(1) Race, The Examination of Milk for Public Health Purposes. John Wiley & Sons. N. Y.
(2) Browne. Jour. Am. Chem. Soc., Vol. 21, p. 823.
(3) Lane-Claypon, Milk and Its Hygienic Relations. Longmans, Green & Co., N. Y.
(4) Lythgoe, H. C., The Composition of Milk as Shown by Analyses of Samples of Known Purity made by the Mass. State Board of Health. Journal of Industrial and Engineering Chemistry, Vol. 6, No. 11.
(5) Publow and Troy, Questions and Answers on Milk and Milk Testing.
(6) Brown and Ekroth, Relation of the Fat in Milk to the Solids-not-Fat. Jour. Ind. Eng. Chem., Vol. 9, No. 3.
(7) Savage, Wm. G., Milk and the Public Health.
(8) Snyder, Dairy Chemistry. The MacMillan Co., N. Y.
(9) Eckles and Shaw, The Influence of the Stage of Lactation on the Composition and Properties of Milk. Bul. 155, Bureau of Animal Industry.
(10) Richmond, H. D., Dairy Chemistry. C. Griffin & Co., London, Eng.
(11) Missouri State Agri. Exp. Sta. Res. Bul. 24.
(12) Missouri State Agri. Exp. Sta. Res. Bul. 25.
(13) Turner, Norton, Shaw and Wright, Effect of Water in the Ration on the Composition of Milk. Reprint, Jour. Agri. Research, Vol. 6, No. 4.
(14) Woodward, Turner and Griffiths, Prickly-pears as a Feed for Dairy Cows. Reprint, Jour. Agri. Research, Vol. 6, No. 5.
(15) Eckles and Shaw, Variations in the Composition and Properties of Milk from the Individual Cow. Bul. 157, Bureau of Animal Industry.
(16) Journal of the Department of Agriculture of South Australia, Vol. 15, No. 5.
(17) Eckles and Palmer, Influence of the Age of the Cow on the Composition and Properties of Milk and Milk Fat. Jour. Agri. Research, Vol. 11, No. 12.
(18) Doane, The Character of Milk During the Period of Heat. Md. Sta. Bul. 95.
(19) Geneva (N. Y.) Agri. Exp. Sta. Bul. 105, New Series.
(20) Murray, J. A., The Chemistry of Cattle Feeding and Dairying. Longmans, Green & Co., N. Y.
(21) Hammer and Johnson, The Specific Heat of Milk and Milk Derivatives, Research Bul. 14, Iowa Exp. Sta.
(22) Bowen, The Application of Refrigeration to the Handling of Milk. Bul. 98.

(22) Bowen, The Application of Refrigeration to the Handling of Milk. Bul. 98, U. S. Dept. Agri.
(23) Wisconsin Agri. Exp. Sta. Rept. 1896, p. 73.
(24) Palmer and Eckles, Carotin—the Principal Natural Yellow Pigment of Milk Fat. Missouri Research Bulletins Nos. 9, 10, 11 and 12.
(25) Experiment Station Record, Vol. 5, p. 973.
(26) Breed, Cells in Milk Derived from the Udder. Geneva, N. Y. Exp. Sta. Bul. 380.
(27) Wing, H. H., Milk and Its Products.
Stocking, Manual of Milk Products.
Van Slyke, Modern Methods of Testing Milk and Milk Products.
Eckles and Shaw, The Influence of Breed and Individuality on the Composition and Properties of Milk. Bul. 156, Bureau of Animal Industry.
Gowen, Variation and Mode of Secretion of Milk Solids. Jour. Agri. Research, Vol. 16, No. 3.
Cooledge, Studies upon the Bacterial Flora of Samples of Milk with High Cellular Content as Drawn from Apparently Normal Udders. Mich. Tech. Bul. 41.
Shaw and Eckles, The Estimation of Total Solids in Milk by the Use of Formulas. Bul. 134, Bureau of Animal Industry.
Farrington and Woll, Testing Milk and Its Products.
Gowen, The Variation of Butter-fat Percentage with Age in Jersey Cattle. Bul. 290, Maine Exp. Sta.

CHAPTER V

BACTERIOLOGY AS APPLIED TO MARKET MILK

WHAT BACTERIA ARE

Bacteria are minute organisms invisible to the naked eye. There has been considerable dispute as to whether they belong to the animal or vegetable kingdom; but it is now thought that they are vegetable cells. Bacteria are colorless bodies and are so small that 8 billion of them could occupy a space the size of a pin head.

Bacteria are normally found practically everywhere; they are in the air, water, soil, on growing grain, in the bodies of animals, etc. They are usually found in relatively small numbers in milk as it comes from the udder of the cow.

HOW BACTERIA GROW

The means by which bacteria multiply is quite simple. The cell elongates, becomes constricted, and finally separates, forming two distinct individual cells. Under very favorable conditions this process may be repeated every twenty or thirty minutes. However, as bacteria grow they elaborate certain by-products which after a time renders the medium unfavorable for further growth. An illustration of this is found in the ordinary souring of milk. When the bacteria which break down milk sugar have produced a certain amount of lactic acid, the milk becomes unsuitable for the further growth of most lactic acid organisms.

Elements necessary for bacterial growth are warmth, moisture, food and oxygen. While some bacteria multiply slowly even at the freezing point and some multiply at 150–160° F., a temperature of about 70° to 100° F. is most favorable. The temperature at which an organism grows most rapidly is called the "optimum" temperature for that organism.

Bacteria live largely on organic matter, especially on substances such as meat, milk and eggs, which contain considerable protein. The food supply of bacteria must furnish nitrogen, carbon and mineral salts, such as phosphates, sulphates, chlorides, and iron. Some bacteria can derive their nitrogen from non-protein substances.

Many forms of bacteria need air in order to maintain growth, and are therefore termed "aerobic." Some few forms will not grow in the presence of air, and are called "anaerobic." Others will grow either with or without air and are classed as "facultative anaerobic" bacteria.

Some bacteria have "spores," which are small round or elliptical bodies contained within the organism. These spores do not multiply; but when the organism is subjected to unfavorable influences, it disintegrates and releases the spore. In this condition the spore can survive extreme heat, drying, and other unfavorable environment for many years. If it is again placed under favorable conditions, the organism begins again to vegetate and reproduce in a normal manner.

Some years ago, the theory was held that fresh milk contained so-called "germicidal properties." It was believed that some substance was present which killed off some of the bacteria. This theory was based on the fact that the bacterial count in fresh milk decreases slightly for a period of two or three hours, when it begins to increase. We now believe that this phenomenon is due to the grouping together or "clumping" of the organisms, whereby a cluster of bacteria appears as only one colony in the plate method of counting. This method of counting will be explained later.

SOURCES OF BACTERIA IN MILK

The statement is often made that milk is practically sterile as it comes from the udder of the cow. Such a statement is misleading. Of course, animals with pathological conditions of the udder may excrete large numbers of bacteria with their milk. Most investigators have found that apparently normal udders harbor bacteria, sometimes in great numbers. Evans (1) found the bacterial count of milk from normal udders to range from 0 to 300,000 per cubic centimeter. In the samples examined, 16.1 per cent contained so few bacteria that their significance was negligible. This investigator found streptococci in 15.1 per cent of the udder samples, but states that *Streptococcus lacticus* is rarely found in the normal udder. Streptococci ranged from a few to 264,000 per cubic centimeter. Micrococci were found in 58.8 per cent of the samples, the general group known as *Micrococcus lactis* being most common, together with *Staphylococcus aureus* and *Staphylococcus albus*.

Bacteria of the *Bacillus abortus* type were common, being found in 23.4 per cent of the samples of udder milk. The majority of udder organisms seem to be of the same types as those found on the skin and mucous membranes of man and other animals, principally streptococci, staphylococci and bacilli.

After milk leaves the udder, it is subjected to innumerable opportunities for contamination, mainly from the body of the cow, the air, the clothing and hands of the milker, and dairy utensils. Manure from the cow's body may introduce many types of bacteria; streptococci and bacilli of the colon type are abundant in manure. Specific disease organisms may be introduced into milk from manure, the hands of the milker, contaminated water supplies, flies, etc.

CLASSIFICATION OF BACTERIA

In a general way, bacteria may be divided into two great groups; namely, pathogenic and saprophytic. Pathogenic bacteria are those capable of producing illness or pathological conditions, while saprophytic bacteria are either harmless or helpful. In market milk, all types of bacteria are, of course, undesirable, for even saprophytes may produce changes which injure the commercial value of the milk.

A further step in the classification of bacteria is to group them according to their "morphology," or structural characteristics.

The following classification is one of several that have been suggested:

Order.	Families.
A. Myxobacteriales	
B. Thiobacteriales	
C. Chlamydobacteriales	
D. Actinomycetales	1. Actinomycetaceae 2. Mycobacteriaceae
E. Eubacteriales	1. Nitrobacteriaceae 2. Pseudomonadaceae 3. Spirillaceae 4. Coccaceae 5. Bacteriaceae 6. Bacillaceae

There are other subdivisions under this classification but these are the main groups.

In studying the action of bacteria on milk, a different grouping, suggested by Ayers, is sometimes made, as follows:

1. Acid-forming organism.
2. Alkali-forming organism.
3. Peptonizing organism.
4. Inert organism.

As indicated by the names, the acid- and alkali-forming organisms produce acid and alkali, respectively; the peptonizing organisms digest milk casein; and the inert type have no visible effect on milk.

The last step in the classification of bacteria is to identify specific named organisms within the groups. This is done by a study of morphology and the growth of the organism on certain media used for differentiation. These named varieties are separate and distinct, as *corynebacterium diphtheriae* (the organism causing diphtheria), *Bacillus typhosus* (the organism causing typhoid fever), etc.

FIG. 7.—A variety of bacteria liable to be found in milk. 1 and 2, typhoid bacillus (Pfeiffer); 3, pus and pus cocci; 4, B. dysenteriæ (Shigar); 5, Proteus vulgaris; 6, Clostridium butyricus; 7, 9, 10, and 11, types of common lactic bacteria (Conn); 8, a coccus without influence on milk (Conn); 12, 13, 14, three bacilli producing slimy milk (Marshall); 15, 16, 17, 18, 19, types of liquefying and putrifying bacteria which digest casein (Conn). Reprinted from Conn's "Bacteria in Milk and Its Products." P. Blakiston's Son & Co., Phila., Pa.

COUNTING BACTERIA IN MILK

The number of bacteria in milk is usually ascertained by means of the standard plate method. A medium favorable to bacterial growth is inoculated, while in a fluid state, with a measured quantity of the milk to be examined. The mixture of milk and medium is placed in a sterile, covered glass dish. As the medium cools, it hardens and holds fast each

FIG. 8.—Placing milk in sterile dish—one of the steps in making a plate count of bacteria.

FIG. 9. Counting colonies of bacteria by the plate method.

organism. The plate is then placed in an incubator where an optimum temperature for bacterial growth is maintained. The organisms grow and form families, or "colonies," which, in a few days, are large enough to be seen with the naked eye. These colonies are counted, and, as each has developed from an organism, the number of colonies approximates the original number of bacteria. Plate counts show a lower number of bacteria than are actually present in the milk, for two reasons; first, not all of the bacteria will multiply on a given medium and second, some colonies may be the result of the growth of a number of organisms which have clung together in a clump.

METHODS OF DIFFERENTIATING BACTERIA

As previously stated, the principal methods of classifying bacteria are direct microscopic examinations, habits of growth in differential media, and animal inoculation.

Direct microscopic examination is made of "hanging drops" containing organisms in a fluid medium, and of stained slides. Hanging drops reveal motility and other characteristics, while stained slides show the size, shape, etc., of the organisms. "Acid-fast" bacteria, among which is the bacillus causing tuberculosis, are distinguished from non-acid-fast varieties by first staining with red, decolorizing with sulphuric acid and alcohol and then staining with a blue stain. The acid-fast bacteria retain the original red stain, while other organisms and debris are blue. This is called "counter-staining."

Animal inoculation is sometimes used to verify classification. Certain pathogenic organisms produce typical lesions in experimental animals.

Differentiation by means of growth on special media is perhaps the most widely used means of distinguishing bacteria. Space does not permit a discussion of all special media, for research students in bacteriology have developed a vast number, only a few of which are used in routine milk examination. Each organism has some peculiarity in its method of growth or its effect on some particular culture medium.

Some organisms liquefy gelatin; some cloud beef-broth or form a characteristic film on its surface; some produce colonies distinctive in their shape, size, color, etc.; some change the reaction of the medium; and some ferment sugars, starches, and alcohols, producing gas or acid, or both.

In public health work, the examinations ordinarily made are as follows:

1. Plate method on beef-agar for total count.

2. Cultivation on Endo's medium. This is a solid, bluish medium on which bacteria of the colon type produce characteristic colonies, having a greenish, metallic sheen.

3. Cultivation in lactose bile broth. These cultures are centrifuged and the sediment stained to determine streptococci.

4. Fermentation of a sugar broth, usually lactose or dextrose, to show gas production. Used in the determination of bacteria of the colon type.

SIGNIFICANCE OF CERTAIN TYPES OF BACTERIA IN MILK

The significance of results obtained by these methods has been a much discussed question. Health departments have, in many cases, considered that bacilli of the colon type were positive evidence of manurial contamination, and that streptococci proved that the cows producing such milk had diseased udders. Research workers in dairy bacteriology have, however, refuted these assumptions and maintain that more complete differentiation should be made before condemning the milk. Rogers and his co-workers (2) have found bacteria of the colon type on certain grains. In view of this work, bacteria of the colon type, while furnishing presumptive evidence, cannot be considered conclusive proof of manurial contamination. (3)

Streptococci may be present in an apparently normal udder. They may be introduced into milk by manurial contamination, from dirty utensils, or from diseased udders of cows suffering from mastitis. Savage (4) states that he found streptococci present in all milk samples, when 1 cubic centimeter or more of milk was used for examination. Evans found that there are two main types of streptococci found in milk, *Streptococcus pyogenes* and *Streptococcus lacticus*. *Streptococcus pyogenes* is a long, chained type coming from inflammatory processes, while *Streptococcus lacticus* is a supposedly harmless type. Not all long-chained streptococci are harmful, however.

Long-chained streptococci usually curdle litmus milk and then reduce the litmus; but they do not completely decolorize it. On the other hand, *Streptococcus lacticus* first reduces the litmus and then curdles the milk, the decolorization being complete below the sharply defined, pink surface layer.

Ayers, Johnson and Davis (5) advise the use of the limiting hydrogen-ion concentration in differentiating between pathogenic and non-pathogenic streptococci. They state that pathogenic streptococci produce less acid from carbohydrates and other test substances than do other types. They recommend a dextrose-yeast-peptone medium in

which pathogenic streptococci reach a limiting hydrogen-ion concentration of *p*H 5.4 to 6. The limits of non-pathogenic streptococci are from *p*H 4.5 to 4.9.

Frost has proposed a method of differentiation into four groups based on the size of the nucleus and the zone of hemolysis when hemolytic streptococci are grown on blood agar.

It is now quite generally accepted that septic sore throat in man is caused by *Streptococcus epidemicus*. A method of examination for this organism will be found in the Appendix giving the methods and standards for certified milk. (See Item 63.)

DESTRUCTION OF BACTERIA

By Chemicals.—Numerous chemical substances have the power of destroying bacteria or inhibiting bacterial growth in milk. Most of these chemicals are poisonous to human beings, or are injurious to health when taken into the body For this reason, the addition of any chemical " preservative " to milk or cream is strictly prohibited in the United States, usually under penalty of a jail sentence. Some countries still allow the use of borax or boracic acid in cream and butter, but the weight of scientific opinion is against such procedure. The chemical preservatives most common before their use in milk was prohibited were borax, boracic acid, salicylic acid, formaldehyde, hydrogen peroxide, and substances containing available chlorine. For the treatment of dairy utensils certain solutions are used which depend on available chlorine for their germicidal action. These substances are usually sodium or calcium hypochlorites or chloramine compounds.

By Heat.—Different types of bacteria are killed by varying degrees of heat applied for various lengths of time. The time and temperature necessary to kill a particular strain of organism is known as its " thermal death point." Fortunately, the thermal death point of pathogenic bacteria is relatively low. The modern process of pasteurization makes use of this fact by destroying disease-producing bacteria at temperatures low enough to avoid injuring the nutritive properties of the milk. The organism causing tuberculosis is destroyed at a temperature of 142°–145° F. maintained for twenty to thirty minutes. Harmful streptococci are killed in thirty minutes at 140° F. Some non-virulent types of streptococci are able to resist higher temperatures, but all are destroyed in thirty minutes at 165° F. A pasteurizing temperature of 142° F., maintained for thirty minutes, will positively kill all pathogenic bacteria in milk. Spore-forming bacteria may resist temperatures even as high as boiling, but fortunately no harmful bacteria

commonly found in milk are of this variety. In treating dairy utensils to kill bacteria a temperature of 205° F. for five minutes is deemed sufficient for all practical purposes.

By Cold.—Bacteria generally are not killed by cold. Their growth is checked at varying low temperatures, but they retain their vitality and again vegetate when conditions become favorable.

MOLDS AND YEASTS

Molds and yeasts are frequently present in milk and other dairy products. Yeasts are closely related to bacteria. They are round or oval microscopic cells, larger than bacteria and differing from the latter in their mode of multiplication. Yeasts multiply by "budding." In this process, a bud or offshoot appears on the side of the parent. This bud grows until it reaches mature size, when it may either detach itself from the parent cell or hang to it. Yeasts usually cause alcoholic fermentation, breaking down sugar into alcohol and carbon dioxide; but this type of alcoholic fermentation rarely occurs in milk.

Molds are still larger, and of a more complex structure. They are masses of branching threads, often visible to the naked eye, and under the microscope they very much resemble tiny plants. Each "plant" sends up branches which are crowned with spores for reproduction like the seeds of a flower.

From a sanitary standpoint, yeasts and molds are believed to have little or no significance in milk. They may show that the milk is old, or has been in contact with improperly cleaned apparatus. However, yeasts and molds are found in milk only in small numbers, and ordinarily do not produce changes dangerous to health.

REFERENCES

(1) Evans, The Bacteria of Milk Freshly Drawn from Normal Udders. Jour. Inf. Dis., Vol. 18, No. 5.
(2) Rogers, Clark and Evans, The Characteristics of Bacteria of the Colon Type Occurring on Grains. Jour. Inf. Dis., Vol. 17, No. 1.
(3) Rogers, Clark and Evans, Colon Bacteria and Streptococci and their Significance in Milk. Jour. Public Health, Vol. 6, No. 4.
(4) Savage, W. G., Milk and the Public Health.
(5) Ayers, Johnson and Davis, The Thermal Death Point and Limiting Hydrogen-Ion Concentration of Pathogenic Streptococci. Jour. Inf. Dis., Vol. 23, No. 3.
Bacteria in Milk. Farmers' Bul. 490.
Stocking, Problems of the Milk Producer. Circ. 110, N. Y. State Dept. Agri.
Conn. Practical Dairy Bacteriology.
Lane-Claypon, Milk and Its Hygienic Relations.

Ayers and Johnson, A Study of the Bacteria which Survive Pasteurization. Bul. 161, Bureau of Animal Industry.

Ayers and Johnson, Ability of Streptococci to Survive Pasteurization. Jour. Agri. Res., 1914, 2, 321.

Rogers and Dahlberg, The Origin of some of the Streptococci Found in Milk. Jour. Agri. Res., Vol. 1, No. 6.

Rogers and Davis, Methods of Classifying the Lactic-acid Bacteria. Bul. 154, Bureau of Animal Industry.

Rogers, Clark and Lubs, The Characteristics of Bacteria of the Colon Type Occurring in Human Feces. Jour. of Bact., Vol. 3, No. 3.

Rogers, Clark and Evans, The Characteristics of Bacteria of the Colon Type Found in Bovine Feces. Jour. of Infectious Diseases, Vol. 15, No. 1.

Brew and Dotterrer, The Number of Bacteria in Milk. Geneva, N. Y., Exp. Sta., Bul. 439.

Breed and Brew, The Control of Bacteria in Market Milk by Direct Microscopic Examination. Geneva, N. Y., Exp. Sta., Bul. 443.

Clawson, Varieties of Streptococci with Special Reference to Constancy. Jour. Inf. Dis., Vol. 26, No. 2.

Jones, Source and Significance of Streptococci in Market Milk. Jour. Exper. Medicine, April, 1920.

Orla-Jensen, Dairy Bacteriology.

CHAPTER VI

ESSENTIAL FACTORS IN PRODUCING MILK OF LOW BACTERIAL COUNT

Factors involved in the production of clean milk may be divided into two general classes, those that affect the total bacterial count and those that do not. In the latter class are included such items as water supplies, ventilation, light, etc. These factors are fully discussed in the chapters on " Milk and the Public Health," and " Dairy Farm Inspection."

Those that affect the bacterial count may be again subdivided into two groups, namely, major and minor factors. All of these are discussed in the chapter on " Dairy Farm Inspection." Four factors, however, have such a tremendous influence on the bacterial content of milk that they deserve special attention. They are clean cows, small-top milking pails, sterilized utensils, and prompt and efficient cooling. Without the proper use of these " Big Four " essentials, satisfactory bacterial counts cannot be secured in market milk.

CLEAN COWS

Under farm conditions cows accumulate on their bodies quantities of manure, mud, dust, chaff, scurf and loose hairs. Practically all of these deposits carry more or less bacteria. If the accretions are on the cows' flanks, bellies, udders or teats, there is a very good chance that they will fall into the milk pail during the process of milking. This results in contamination of the milk, often with undesirable types of organisms. Ayers, Cook and Clemmer (1) found that a gram of fresh cow manure contained an average of 49,645,614 bacteria.

The same investigators conducted a series of experiments to ascertain the effect of certain sanitary practices upon the bacterial content of freshly drawn milk. The effect of dirty cows upon the cleanliness of milk is plainly shown in Table 18, which has been compiled from averages obtained in their experiments.

From this table it may be seen that, with dirty cows, washing the udders and teats reduced the bacterial count from over 22,000 to about

6000 per cubic centimeter. When the cows were cleaned, besides having their udders and teats washed, the count was further reduced to 2154 per cubic centimeter. In short, all other conditions being the same, thorough cleaning of the cows reduced the bacterial count of freshly drawn milk from 22,677 to 2154 bacteria per cubic centimeter.

TABLE 18

Effect of Dirty Cows on the Bacterial Count of Milk

Conditions.	Average Count per Cubic Centimeter.
Cows dirty, open pail, utensils treated to kill bacteria	22,677
Cows dirty, open pail, utensils untreated, udders and teats washed	6,166
Cows clean, open pail, utensils treated, udders and teats not washed	4,524
Cows clean, open pail, utensils treated, udders and teats washed	2,154

Fig. 10.—Washing cow's udder, teats and flanks before milking.

Cows should be thoroughly groomed to keep them free from accumulations of manure, dirt and loose hair. Clipping long hairs on the udder, flanks and belly facilitates proper cleaning. Grooming is better done about an hour before milking, so that the dust will have time to settle.

The best results can be secured only when udder and teats are washed or wiped with a clean, damp cloth, just previous to milking. The

method used depends to a great extent upon the condition of the cows; when udders and teats are soiled with manure or mud, washing with clean water is necessary. Water should be changed frequently, so that a clean supply is always in use. After washing, surplus moisture should be removed by wiping with a dry or slightly damp cloth, so that there will be no surplus water to drip into the milk pail, or wet the milker's hands. When milking starts, the udders, teats and flanks should be clean and slightly damp.

SMALL-TOP MILKING PAIL

Since, under bad conditions, considerable amounts of dirt may fall from the cow into the milk pail, the use of a hooded or small-top milk pail is advocated. Many types have been devised and are on the market. In selecting such a pail, the points to be considered are, ease of cleaning, smallness of opening, and ease of use.

Pails should be free from acute angles and inaccessible crevices and parts which make thorough cleaning difficult. All seams should be flushed with solder to facilitate cleaning. At first, dairymen often object to small-top pails on the ground that it is difficult to milk into the opening. If a proper pail is selected, very little practice is necessary to acquire the requisite dexterity. Fig. 11 shows a small-top milking pail which gives very satisfactory results. It can be made by soldering the hood on to an ordinary milk pail—a job that any tinner can do. It is surprising, even under good conditions, to see the amount of hair and dirt that will collect on the cover of such a pail during milking. Without the hood, this material would fall directly into the milk.

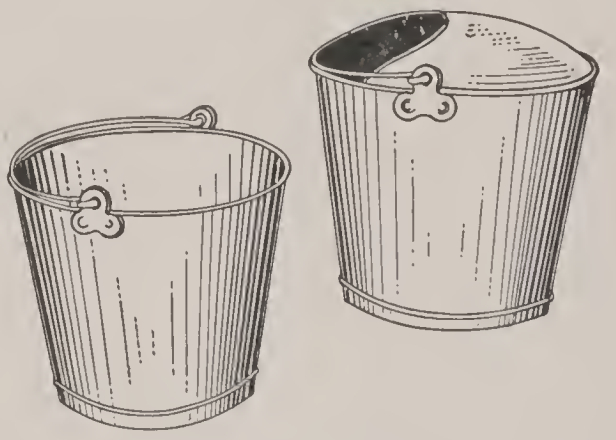

Fig. 11.—Small-mouth milking pail made from an ordinary milk pail by the addition of a hood.

The investigators previously mentioned in this chapter (1) found that the small-top pail was an important factor in lowering the bacterial count in milk. Their findings coincide with the results of Harding, (2) Stocking, (3) North, Prucha (4) and others. Table 19 shows the effect of the small-top milk pail in various experiments made by Ayers, Cook and Clemmer.

TABLE 19

INFLUENCE OF SMALL-TOP MILKING PAILS ON THE BACTERIAL COUNT

Conditions.	Bacteria per Cubic Centimeter, Average	
	Open Pail.	Small-top Pail.
Cows dirty, utensils treated to kill bacteria.....	86,212	24,439
Cows dirty, udders and teats washed, utensils treated..	6,166	2,886
Cows clean, udders and teats washed, utensils treated..	4,947	2,677

It can be seen from the foregoing table that the small-top milk pail has the greatest effect when the cows are dirty. The reason is apparent: where there is but little dirt to fall, there would be only a slight contamination.

CLEAN UTENSILS TREATED TO KILL BACTERIA

The greatest single influence on the bacterial count of fresh milk is exerted by the utensils. Utensils may appear clean, but unless they are subjected to thorough treatment they may contribute enormous numbers of bacteria to the milk coming in contact with them.

Bulletin 642 of the U. S. Department of Agriculture (1) reports a series of experiments to determine the essential factors in the production of milk of low bacterial content. The authors record a series of sixty dual samples of milk for which both treated and untreated utensils were used. A small-top milking pail was used in all cases. The average bacterial count, when untreated utensils were used, was 73,308 per cubic centimeter; when treated utensils were used, the average count was only 6,306 per cubic centimeter. The results on the individual samples are graphically shown in Fig. 12.

Prompt Washing Necessary.—In order that treatment may be effective, it is necessary thoroughly to wash milk utensils immediately after use. If remnants of milk or milky residue are left on the utensils, there will be a rapid multiplication of bacteria. Furthermore, milk solids dry on the surfaces and are more difficult to remove.

The experiments previously noted in this chapter (1) included one to show the bacterial growth taking place when utensils were not promptly washed. When the utensils were washed directly after milking, the average bacterial count of the subsequent milking was 666,520 per cubic centimeter. Some of the utensils were left unwashed

for eight hours, and then washed in the same manner as the other utensils. In this case, the subsequent milking had an average bacterial count of 1,677,000 per cubic centimeter. In neither of these experiments were the utensils further treated. It can readily be seen that the bacterial count was only one-third as great when the utensils were

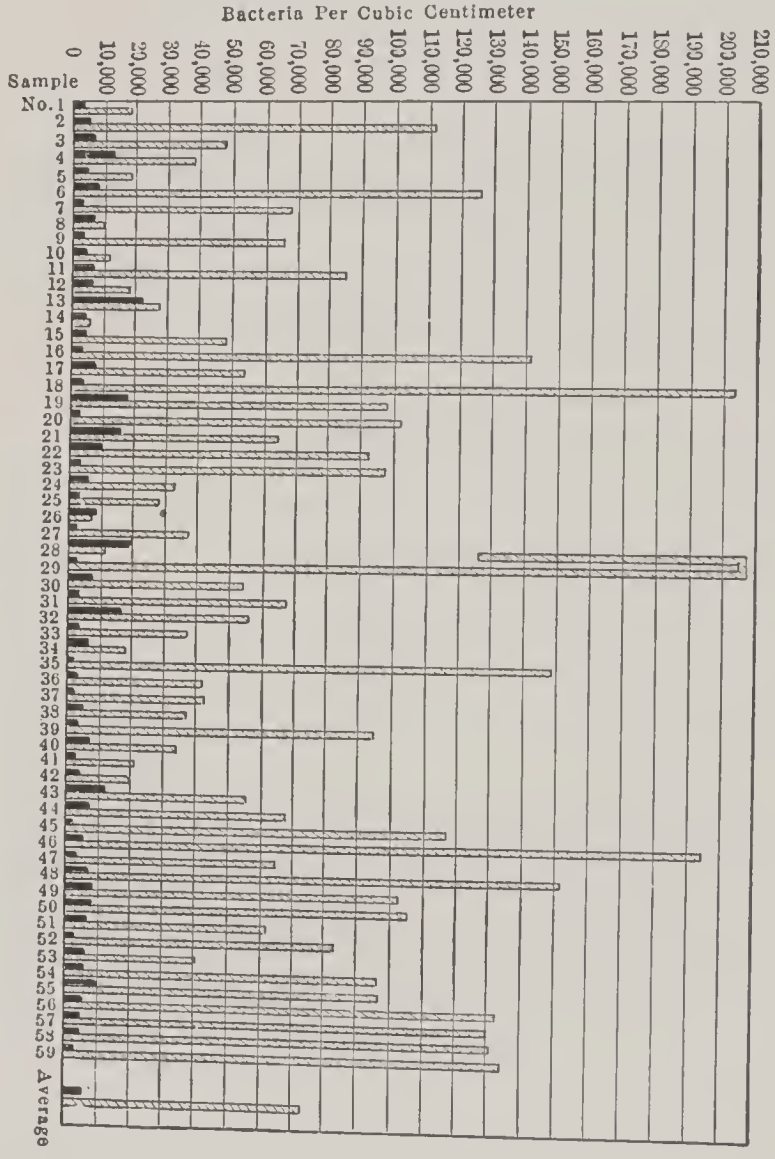

FIG. 12.—Bacterial contents of milk from treated (black) and untreated (shaded) utensils.

promptly washed as it was when they were allowed to remain unwashed for eight hours.

Washing Utensils.—Utensils should first be rinsed in clean, cold or lukewarm water, and then washed in hot water containing an alkali or soda-ash washing powder. It is necessary to scrub them thoroughly with a stiff brush, avoiding the use of wash rags, soaps, and greasy

powders. A final rinsing in clean water prepares the utensils for final treatment.

Steam Treatment of Utensils.—Steam is by far the most satisfactory agent. It is positive in its action, and has the additional advantage of leaving the utensils hot, so that they will dry quickly.

Steam boilers are a valuable adjunct to the farm dairy. They furnish steam for heating wash water, for further treatment of utensils, and for sundry other farm operations. The ideal method of treatment

FIG. 13.—Concrete oven for the steam treatment of dairy utensils.

requires an oven or chamber, which may be made of brick, concrete, metal, or even wood, though the last-named material is not so satisfactory. In this oven may be placed separator parts, cans, pails, coolers, strainers, etc., and live steam from the boiler may be introduced. This steaming process should continue for twenty to thirty minutes. Vents may then be opened to permit the exit of steam and vapor, so that the utensils may dry. The cabinet door must fit tightly to prevent the escape of steam during treatment.

Steam Jet.—A steam jet is sometimes used. Steam is piped from the boiler through a drain-board at one end of the wash sink. The flow of steam is controlled by a hand or foot lever. Cans and pails,

after washing, are inverted over the outlet of the pipe, steam being forced into them by the operation of the lever. This method is not so satisfactory as the oven, for several reasons. The time of steaming (which should be at least five minutes) is usually shortened because of the hurry of the operator; much more steam is used; only the inside of utensils is thoroughly steamed; certain utensils cannot be conveniently treated; and the utensils become very hot, so that they are not easily handled.

Other Steam Appliances.—A very convenient apparatus for moderate-sized dairies is shown in Fig. 14. It supplies hot water for washing, as well as steam, consisting of a metal box slightly larger than is needed to hold all the dairy utensils. The box has a perforated false bottom 3 or 4 inches above the real bottom, and is covered with a tight-fitting cover. At the level of the false bottom, an ordinary faucet is placed. (5)

FIG. 14.—Galvanized tank on brick setting. Used for heating water and steaming dairy utensils.

The tank may be placed on a brick or masonry foundation containing a fire-door in the front. At milking time the tank is filled with water and a fire started beneath. When milking is finished, the tank is full of hot water, which is drawn off through the faucet for washing purposes, and the utensils, after being washed, are placed on the false bottom. The 3 or 4 inches of water remaining beneath the false bottom continue to boil, the steam escaping through the perforations into the upper chamber. Steaming should continue for twenty to thirty minutes, care being taken to prevent the tank from becoming entirely dry, as damage to tank and utensils is likely to result, if this occurs.

A simple steamer for dairy utensils is described in Farmers' Bulletin 748. (6) This apparatus is relatively inexpensive and is very efficient in its action, but is adapted for use only in small dairies where few utensils are to be treated.

Treatment with Hot Water.—If no steam is available, utensils may be treated by boiling in water for five or ten minutes. Rinsing with boiling water is not efficient.

Chemical Treatment.—It is possible to secure good results, in treating dairy utensils, by the use of chemical compounds. Such compounds are on the market under various trade names. They are usually

hypochlorites of either calcium or sodium, and their efficiency depends largely upon the presence of available chlorine. Home-made solutions can be prepared in the following manner:

Making Calcium-Hypochlorite Solutions.—In using calcium hypochlorite, prepare a stock solution by making a smooth watery paste of 12 ounces of commercial chloride of lime containing 30 per cent available chlorine (or 15 ounces of chloride of lime containing 24 per cent available chlorine), and then adding water slowly and stirring thoroughly until the solution amounts to 2 gallons. Then allow to settle and strain into a tightly closed glass bottle or jar and keep it in a cold dark room. Add 1 pint of this stock solution to every 8 gallons of water for the final rinse, which should be used immediately. The used rinse solution should be thrown away and a new one mixed daily. It is advisable not to make larger quantities of stock solution than can be used within two weeks.

Making Sodium-Hypochlorite Solutions.—Make a smooth watery paste of 12 ounces of commercial chloride of lime containing 30 per cent available chlorine (or 15 ounces of chloride of lime containing 24 per cent available chlorine), then add water slowly and stir thoroughly until the solution amounts to 1 gallon.

Dissolve 27 ounces of washing soda (use the common crystals, *not powder or cooking soda*) in 1 gallon of warm water. If chloride of lime containing 24 per cent available chlorine is used, it will require 34 ounces of washing soda.

Mix the two solutions, stir thoroughly, and let stand for several hours. Strain the clear liquid into a tightly closed glass bottle or jar and keep it in a cold dark room.

One pint of this stock solution should be added to every 8 gallons of water for the final rinse.

These rinse solutions contain approximately 200 parts of available chlorine to 1,000,000 parts of water, which is the strength recommended for farm use.

Chlorine compounds in various forms and under numerous trade names are on the market. Their cost is usually more than the home-made solution, but some labor is saved in that no stock solution need be prepared and their strength is usually more uniform.

Dairy utensils may be treated with chlorine solutions in two ways: (1) Immersing, and (2) spraying. Immersing the utensils in a tank containing the chlorine solution insures that the entire surface comes in contact with the chemical. Each utensil should be completely immersed and left for 2 minutes. The spray method may be used for large utensils. It is especially adapted to treatment of coolers in which both water and brine flow. The sprayer should be of the pressure type, capable of covering considerable area with a fine spray.

It is essential that every particle of organic matter be removed before treatment with chlorine compounds, as milk, cream, or organic matter weakens the effect of the chlorine solution on bacteria. The solution should be applied immediately after completion of the washing

process. Turn the utensils upside-down in a clean, dry place free from dust and odors, and do not touch until needed.

In milk plants, somewhat weaker solutions may be used. One-half pint of the stock solution may be added to every 8 gallons of water for the rinse solutions. This makes a dilution of 100 parts available chlorine to 1,000,000 parts of water. If the spray method is used instead of soaking, it is advisable to use the stronger solution—1 pint of stock solution to 8 gallons of water.

Treatment by means of chemical solutions requires care. The soak solution quickly loses its strength and is often used after its effectiveness has passed. In fact, the solutions sometimes have been found to be an actual source of contamination.

Importance of Drying Utensils.—Steaming should leave the utensils so hot that they will dry quickly. This latter point is extremely important. Experiments have shown that bacteria increase rapidly on the surfaces of moist utensils. Table 20 is taken from Department of Agriculture Bulletin 642, and shows the bacterial increase in undried milk cans.

TABLE 20

BACTERIAL GROWTH IN CANS COVERED BEFORE BEING DRIED (1)

Series No.	Bacteria per Can.		Series No.	Bacteria per Can.	
	Freshly Washed.	24 Hours after Washing.		Freshly Washed.	24 Hours after Washing.
1	960,000	847,000,000	5	99,600	320,000,000
2	618,000	2,612,000,000	6	5,570,000	748,000,000
3	137,000	336,000,000	7	305,000	138,000,000

Protection of Utensils from Contamination.—After utensils are treated, they should be protected from contamination by flies, dust, chickens, etc. They may be left in the steaming cabinet until milking time, or they may be inverted on a rack in the milk house or on a screened porch.

Cleaning Milking Machines.—Clean milk can be produced with milking machines, if the apparatus is properly cleaned. In fact, some of the finest dairies use milking machines.

Some milking-machine users employ chemical treatment as previously described; others use steam.

In 1917 Hart and Stabler, of California, (7) started experimental work with heat, but at a lower temperature than had been formerly used. In short, they "pasteurized" the rubber parts in hot water. The results obtained under practical conditions in California led the Bureau of Dairy Industry of the United States Department of Agriculture to pursue extensive research work along similar lines. It was found that treatment with water heated to 160°–170° F., gave excellent results in the hands of the average dairyman. In one year, over 400 samples of milk, taken when machines were treated by the heat method, averaged only 15,300 bacteria per cubic centimeter. The machines properly treated by chlorine solutions drew milk with an average count of 57,700 per cubic centimeter. These were not laboratory experiments, but field trials, where the machines were handled by the usual farm help.

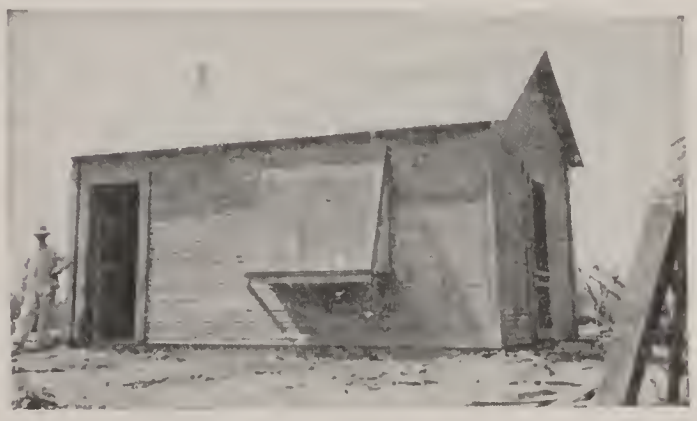

FIG. 15.—Screened rack for drying and sunning dairy utensils after treatment to kill bacteria.

Owing to the construction of milking machines, persistent care must be exercised in cleaning them if milk of high quality is to be produced. Each inspector should become thoroughly acquainted with the construction, operation, and care of the various types of mechanical milkers. The following points should be closely watched in cleaning milking machines: (8)

1. Rubber tubing, including glass unions.
2. Moisture traps.
3. Vacuum lines.
4. Teat cups and inflations.
5. Bucket.
6. Head.
7. Valves and pet cocks.

Immediately after milking, the machines are rinsed with cold or lukewarm water drawn through the machines by vacuum. The flow should be broken occasionally by pulling the teat cups out of the water and then immediately immersing again. This is done ten or twelve times.

The above process is then repeated, with hot soda solution. Teat cups and tubing are washed with a brush at this time.

Units are then rinsed with clean water drawn through by vacuum. Long milk tube, (9) with claw and teat cups, is then detached from head of pail. Air tubes (on inflation types of machines) are plugged, and the whole is placed in a tank of clean water, care being taken that all parts are entirely submerged. The water is then heated to a temperature of 160° to 170° F., and held there for fifteen to thirty minutes. The water is then allowed to cool, and the parts to remain there until the next milking. (A covered tank will usually hold the temperature above 160° F., for the required length of time, if heated to 165° or 170° F.)

After each use the machines should be taken entirely apart and washed thoroughly with brushes and hot soda solution. The vacuum line should be cleaned about every two weeks by drawing hot soda solution through it with vacuum. If milk is drawn into the vacuum line, the pipe should be cleaned immediately after milking.

The moisture trap on the head of the machine (cover of pail) should be cleaned every day.

Milking machine pails and covers should be thoroughly washed and treated to kill bacteria after every milking.

In preparing the cows for milking, the same care should be used as in milking by hand. It is necessary that the teats be very clean if a clean milk is to be obtained.

PROMPT AND EFFICIENT COOLING

Lack of cooling or improper cooling is, without doubt, by far the largest cause of high bacterial counts in milk, as it is received on the average market. We have already shown that bacteria multiply rapidly in a warm medium. If milk is allowed to remain unchilled, bacteria develop rapidly; they may reproduce and double in number once every half hour. Theoretically, a single organism in warm milk would multiply in five hours to over 1000 organisms, or fresh milk containing 50,000 bacteria per cubic centimeter might contain 50,000,000 per cubic centimeter at the end of five hours. Fortunately, bacteria do not often

FIG. 16.—Showing the effect of temperature upon the growth of bacteria. (*a*) a single bacterium; (*b*) its progeny in twenty-four hours in milk kept at 50° F., 5 bacteria; (*c*) its progeny in 24 hours in milk kept at 70° F., 750 bacteria.

increase quite so rapidly in milk, as some die, and some multiply slowly, because of unfavorable conditions. However, there is a tremendous multiplication when milk is not quickly cooled to a low temperature.

This multiplication frequently results in sour milk and other undesirable dairy products. Fig. 17 shows the length of time milk kept sweet at different temperatures in an experimental case.

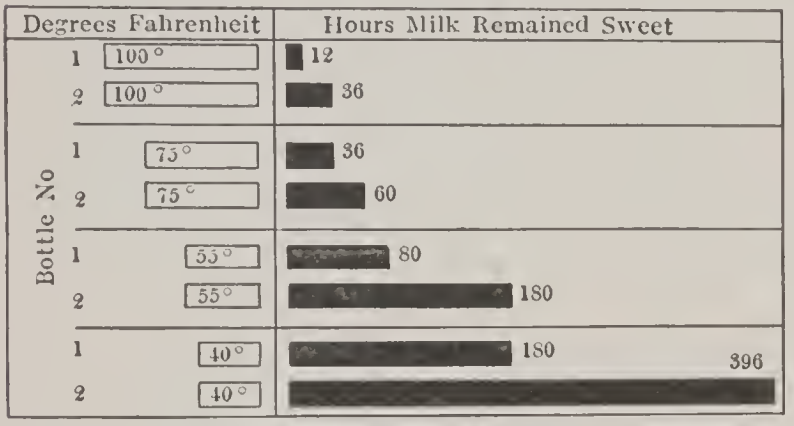

Fig. 17.—Diagram showing time necessary to sour milk of high (1) and low (2) bacterial content at different temperatures.

Prompt Cooling Desirable. — Milk should be cooled as soon as it is drawn from the cow. If cooling is delayed, bacterial multiplication may take place, resulting in a high count, even if the milk is subsequently cooled. If cans of warm milk are placed in a tank of cold water, much time is required to cool the large mass of milk. For this reason, some form of cooler which chills the milk instantly should be used.

Surface Coolers.—Such coolers consist of a metal device containing cold water or brine, over which the milk runs in a thin film. If they are properly installed and operated, it is possible to cool milk instantly to within 2 or 3° of the cooling medium.

Surface coolers make possible a great saving of time in cooling, which is especially advantageous in the morning, when milk must be at the shipping point soon after milking.

The following observations on surface coolers are made in Farmers' Bulletin 976: (10)

" Water at a temperature of from 50° to 60° F. is available for cooling milk on most dairy farms. To obtain the most rapid, efficient, and economical cooling of milk a surface cooler should be used. An apparatus of that kind should be simple, durable, and easy to clean and sterilize. In operating, special attention should be given to regulating the flow of milk over the cooler, in order to obtain the maximum cooling effect. Each cow's milk should be cooled immediately after milking, without waiting for all the cows to be milked. The flow of milk should be so regulated that a continuous but thin stream passes over the cooler throughout the entire period while the cows are being milked. Surface coolers for running water can be used where there is sufficient

water pressure, and other types can be used with ice water, when running water is not available. Pre-cooling, or cooling first with a surface cooler before placing the cans in the cooling tank, not only cools milk more rapidly but saves considerable ice. When cold running water is available, the temperature of warm milk may be lowered from 30 to 50° by using surface coolers. By this means it may be cooled to within 2 or 3° of the temperature of the cooling water.

" Under average conditions, with a surface cooler and running water, from 10 to 15 gallons of water should be sufficient to lower the temperature of each gallon of warm milk to within 3° of the initial temperature of the water. A great loss in cooling efficiency may result during warm weather, if the water used for pre-cooling is allowed to become warm before it is used, which occurs when spring water runs over the surface of the ground before passing into the cooling system, or when water from a storage tank is used for cooling. The warmer the water used for cooling, the more ice will be needed. In cooling 10 gallons of milk, a difference of 10° in the temperature of the water between 50 and 60° F. is equal to the melting of approximately 5 pounds of ice, while the difference in temperature between 50 and 70° F. is equal to the melting of 10 pounds.

" When it is necessary to cool milk quickly to 50° F., or below, as when the morning's milk must be delivered shortly after milking, ice water should be used in the surface cooler, provided it is of a suitable type, instead of spring or well water, as the latter are seldom cold enough to cool milk below 50° F. In the case of the night's milk, when more time is available, it is advisable to cool to within 2 or 3° of the temperature of the spring or well water by means of a surface cooler, and then place the cans of milk in a tank of ice water to remain until time for delivery."

It is advisable to pump water for cooling direct from the spring or well, as shown in Fig. 18.

Types of Surface Coolers.—Many varieties of surface coolers are on the market, but they may be classed in three different groups. The cooler shown in Fig. 19 is filled with ice and water. The milk is poured into the top receptable, from which it runs through small holes over the outside. It is caught by the trough at the bottom and runs through an outlet into a can or bottle filler. The ice and water inside the drum must be kept constantly stirred; otherwise a layer of warm water collects near the metal and destroys the cooling effect.

The apparatus shown in Fig. 20 makes use of running water, which enters the corrugated drum at the bottom, overflowing at the top. The milk runs down the spiral on the outside, coming constantly into contact with a colder surface.

Fig. 21 shows a very common and efficient type of cooler. It may consist of two flat surfaces, corrugated, or of a series of tubes or pipes.

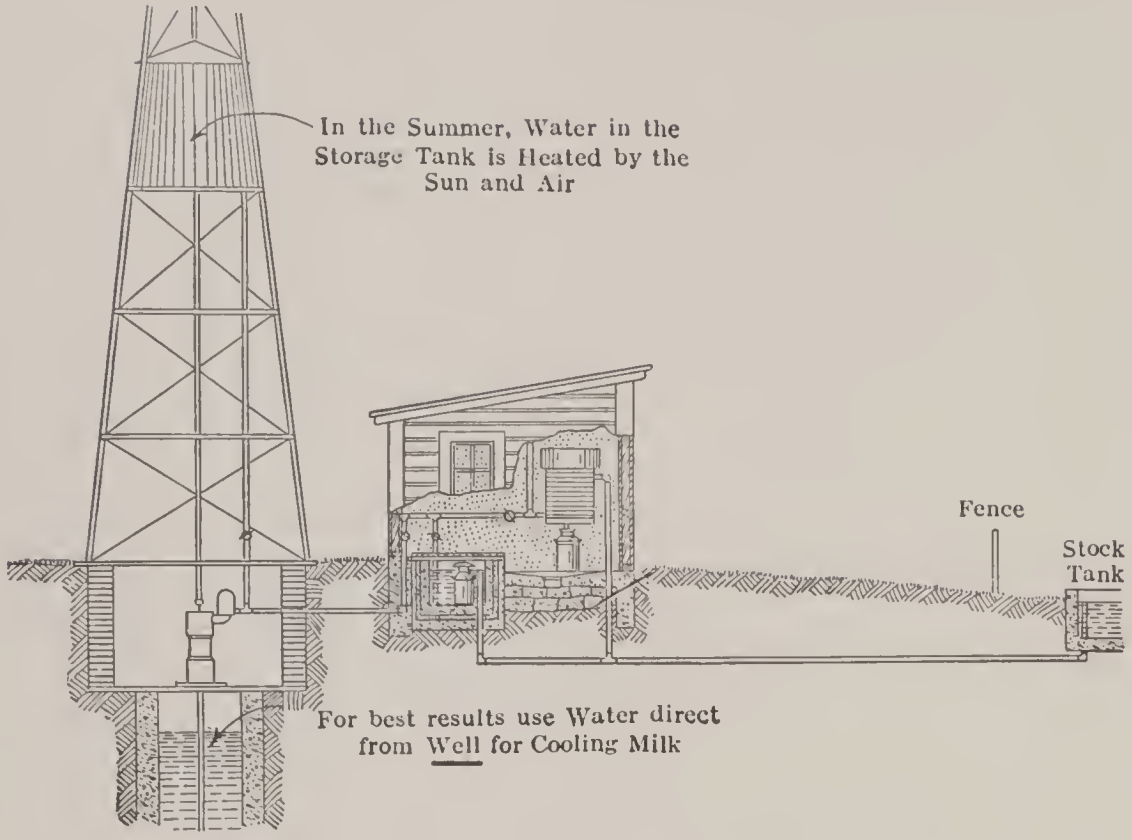
In the Summer, Water in the Storage Tank is Heated by the Sun and Air
Fence
Stock Tank
For best results use Water direct from Well for Cooling Milk

FIG. 18.—Arrangement of water supply for milk house.

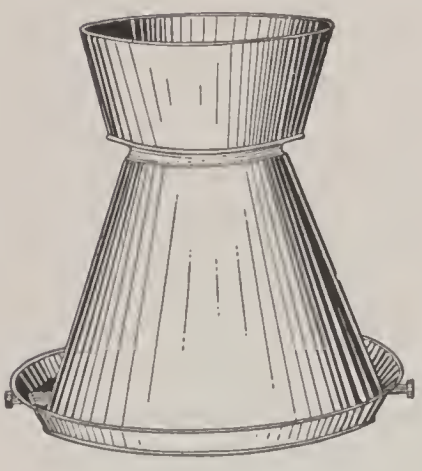

FIG. 19.

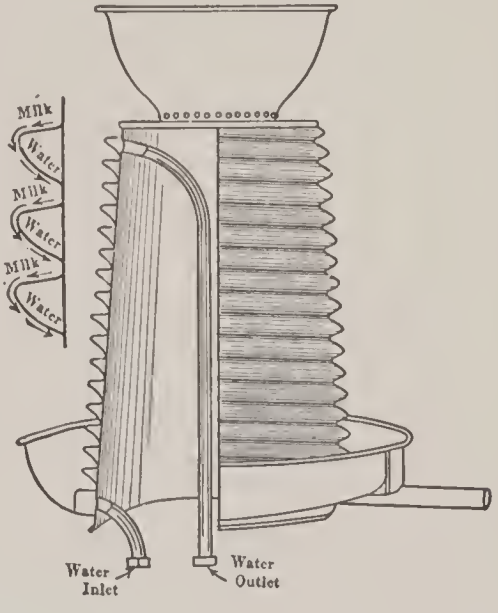

FIG. 20.

FIG. 19.—Conical milk cooler for use with water and ice. To obtain good results the water and ice must be stirred frequently.

FIG. 20.—Spirally corrugated milk cooler for use with running water.

In either case, the cooling medium flows upward on the interior, while the milk passes downward in a thin film over the outside.

Important Points in Surface Cooling.—Coolers are sold by dairy supply houses at rated capacities of so many pounds or gallons per hour. A cooler of ample capacity should be installed, for if milk is forced over the cooler beyond its capacity, inadequate cooling will result.

Water should be available in sufficient quantity and under sufficient head. Failure in this respect also results in inadequate cooling. An

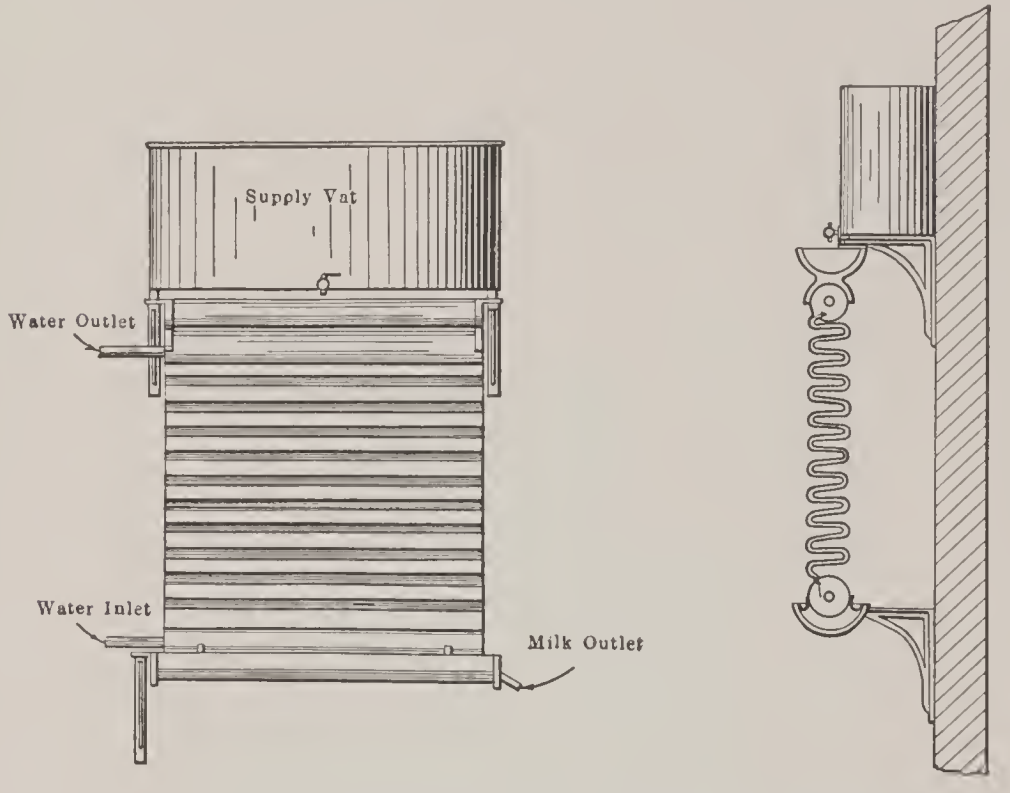

FIG. 21.—Corrugated milk cooler for use with running water.

abundance of cold water should constantly replace that warmed by the milk.

The water piped to the milk cooler should enter at the bottom and discharge at the top. In this way, the warm milk meets the warmest water first, and as it flows downward it meets colder water. The final cooling over the bottom coils or corrugations is done by the coldest water.

Final Cooling and Storage.—If "pre-cooling," or cooling over a surface cooler, is properly done, the milk should be cooled to 60° F. or lower without the use of ice. But bacteria will multiply at this temperature, and further cooling is therefore essential. As soon as cans are filled

with milk from the cooler, they should be set into a tank of ice water for final cooling below 50° F. Before milking is begun, the tank should be filled with clean water in which sufficient ice should be placed to lower the temperature of the water below 45° F. When the milk is placed in water of this temperature, 2 to $2\frac{1}{2}$ pounds of ice should cool and hold each gallon of milk at 50° F. If milk is not pre-cooled before being placed in a tank of water having a temperature of 45° F., 4 pounds or more of ice is needed to cool each gallon of milk to 50° F. Thus, pre-cooling saves practically one-half of the ice used in tank cooling alone.

In places where no ice is available, milk may be stored in tanks supplied with cold running water. Sometimes there is no running water supply. In such cases, arrangements should be made to have all water pumped for livestock or other purposes pass through the milk tank first. Storage in water is not very satisfactory unless the water is unusually cold. Ice is practically essential, and should be provided wherever possible.

During the past few years mechanical cooling systems have been quite widely adopted for use on farms. Systems using ammonia, sulfur dioxide, or methyl chloride and operated either by electric current or heat (the absorption method) are commonly used. Their development has been rapid, and in many cases they are cheaper than the purchase of ice for cooling and storage. Even in regions where natural ice is available and cheap they have found favor on account of their neatness, freedom from dirt and slop, and compactness.

Owing to the lack of proper cooling and storage facilities on many farms, it is better to carry the warm milk twice a day soon after milking to the receiving station or plant. There it may be properly cooled before any extensive bacterial growth has taken place. This is far better than allowing it to remain overnight on the farm at relatively high temperatures.

Location of Cooler and Storage Tank.—Milk coolers and storage tanks should be located in a milk room or milk house. In surface cooling, milk is exposed in a thin film to the air. Thus, it is necessary to conduct the cooling process in a place free from dust, odors and flies. A clean, properly screened milk house is best for this purpose.

Tanks placed outdoors are not so efficient, for much ice is wasted by heat and exposure. Covered tanks have been found to be much more efficient than uncovered ones, as the covers prevent absorption of heat from the air.

Efficiency of Different Types of Tanks.—Gamble and Bowen (11) tested very thoroughly the efficiency of tanks of different materials, operated under varying conditions. They found that an insulated tank was most efficient. Other tanks followed in this order: wood,

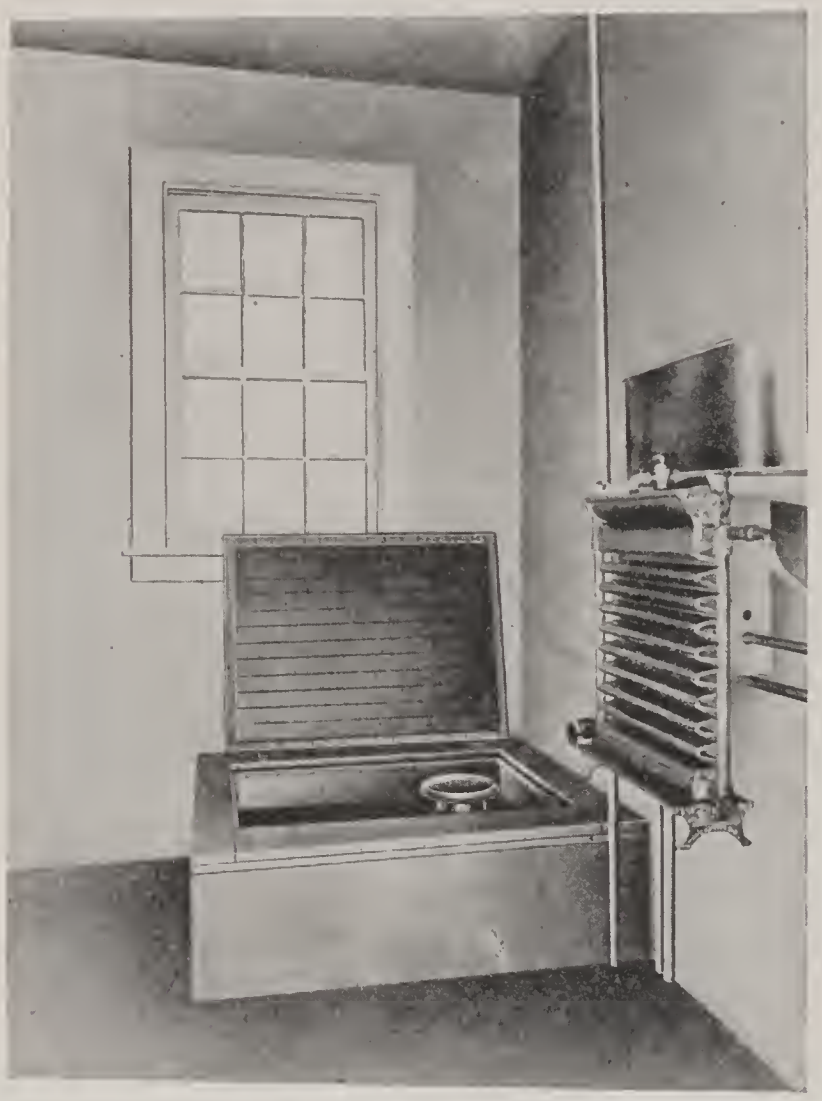

FIG. 22.—Milk cooler and insulated storage tank with cover.

concrete, and galvanized iron. Although the insulated tank involved a greater first cost, it was found to be so economical of ice as to pay for itself in the first season.

Table 21 shows the relative efficiency of the tanks used in the experiments, in terms of pounds of ice melted.

Size of Tank.—Great care should be exercised in securing a tank of the correct size. If the tank is too large, a great amount of surplus water must be cooled, thus wasting ice; if it is too small, it will not hold

an adequate quantity of water and ice. When ice is used for final cooling and storage, the tank should contain about 3 gallons of water for each gallon of milk. If no ice is used, there should be at least 6 gallons of water for each gallon of milk.

TABLE 21

Loss of Cooling Effect in Nine Hours at an Average Air Temperature of 84.2° F. in Each of Four Types of Milk-cooling Tanks under Various Conditions of Exposure

Expressed in Terms of Pounds of Ice Melted

Type of Tank.	Tanks Without Covers, Exposed to Sun. Pounds.	Tanks Covered Exposed to Sun. Pounds.	Tanks Without Covers in Milk House. Pounds.	Tanks Covered in Milk House. Pounds.
Galvanized-iron tank	168	111	107	84
Plain concrete tank	137	88	80	61
Wooden tank	107	38	50	30.5
Cork-insulated wooden tank	80	12	30	7.6

Figuring Size of Tank.—Suppose 30 gallons of milk are to be cooled. One gallon contains 231 cubic inches. Then 30 by 231 equals 6930 cubic inches of milk. Add, say, 5 per cent for the cans.

6930 milk
346 cans

7276 cubic inches

If ice is used, there must be 3 gallons of water for each gallon of milk. Then $90 \times 231 = 20{,}790$ cubic inches of water.

Cans and milk = 7,276 cubic inches
Water = 20,790 cubic inches

28,066 cubic inches

The tank must have a capacity of 28,066 cubic inches to the overflow or drain.

Construction of Tank.—The cooling tank must be well made and water-tight. Two-inch plank can be used for wooden tanks. All seams

should be tightly closed and painted with white lead. The cans should set in the tank on a rack, so that water can circulate under them. Water should come well up on the necks of the cans, so that all parts of cans containing milk are surrounded by water. A drain pipe or overflow should be so arranged that the water will overflow at the proper height.

It is well to provide for fluctuations in the milk supply, so that the tank will be of the right size at all seasons. This may be done by dividing the tank into two parts, when building it. One compartment may be two-thirds the size of the entire tank; the other, one-third. This gives a tank capacity of three different sizes. Either one of the compartments may be used alone, or both may be used.

Building an Insulated Tank.—The following directions for building an insulated tank are from Farmers' Bulletin 976: (10)

"While from the point of view of cooling, wooden tanks give good results, an insulated concrete tank is much more desirable, as it is easily built and can be set partly in the ground. A wooden or galvanized-iron tank does not last long under similar conditions. When the tank is set low, cans of milk can be lifted in or out with much less effort than when it is entirely above the ground. The total thickness of the walls of an insulated concrete tank should be 8 inches, divided into two walls, the outside being 2 inches, then 2 inches of good insulation and the inside wall 4 inches thick. The concrete mix should consist of 1 part Portland cement, 2 parts clean, sharp sand, and 4 parts broken stone or gravel. For the purpose of waterproofing, hydrated lime equal to 10 per cent by weight of the cement should be added to the mixture. The insulation used should be coated with and set in hot asphalt which should be allowed to become thoroughly dry before the inner walls of the tank are put up. The inside walls should be very carefully troweled so as to insure a smooth surface without projecting particles."

Storage and Shipment.—Cans of milk should be left in the storage tank until time for shipment. They should be loaded without unnecessary delay. In hauling to the creamery or railroad station, a blanket or felt jacket should be placed over the cans.

REFERENCES

(1) Ayers, Cook and Clemmer, The Four Essential Factors in the Production of Milk of a Low Bacterial Content. D. B. 642, U. S. Dept. Agri.

(2) Harding, Ruehle, Wilson and Smith, The Effect of Certain Dairy Operations upon the Germ Content of Milk. N. Y. (Geneva) Agri. Exp. Sta., Bul. 365.

(3) Stocking, Comparative Studies with Covered Milk Pails. Conn. (Storrs) Agri. Exp. Sta., Bul. 48.

(4) Prucha, Utensils as a Source of Bacterial Contamination of Milk. Science, N. S., v. 42, No. 1080, p. 353.
(5) Circ. 179, University of California, College of Agriculture, Berkeley, Calif.
(6) Ayers and Taylor, A Simple Steam Sterilizer for Farm Dairy Utensils. F. B. 748, U. S. Dept. Agri.
(7) Hart and Stabler, Experiments With and Practical Application of Heat Sterilization for all Parts of Milking Machines. Jour. Dairy Science, Vol. 3, No. 1, p. 33.
(8) U. S. Dept. Agri., Health Officer Letters 36 and 37.
(9) U. S. Dept. Agri., Milk Plant Letter 94.
(10) Gamble, Cooling Milk and Cream on the Farm. F. B. 976, U. S. Dept. Agri.
(11) Gamble and Bowen, Cooling Milk and Storing and Shipping it at Low Temperatures. D. B. 744, U. S. Dept. Agri.
Kelly, Production of Clean Milk. F. B. 602, U. S. Dept. Agri.
Stocking, Quality of Milk Affected by Common Dairy Practices. Conn. (Storrs) Agri. Exp. Sta., Bul. 42.

CHAPTER VII

ORGANIZATION OF MILK CONTROL

NECESSITY FOR MILK CONTROL

It has already been shown that human health is, to a considerable extent, dependent upon a pure milk supply. Furthermore, the consumer is entitled to full value in food material for the money expended for milk. In the early days, it was not uncommon to find dealers delivering milk which was filthy, and so teeming with bacteria that it would keep sweet only a few hours. Under such conditions, milk was frequently treated with chemical preservatives to prolong its keeping qualities. Such preservatives, without exception, were injurious to health. They also allowed the use of milk which, while sweet to the taste, was unfit for human consumption. Skimmed and watered milk was also sold by unscrupulous dealers. The public was thereby defrauded and children cheated of the nourishment they should have had.

GROWTH OF MILK INSPECTION

Because of these conditions existing in the milk trade, dairy and milk inspection was instituted. The consumer was in no position to test the purity and food value of milk. It therefore became necessary for some public agency to take the matter up and stand between the milk distributor and the public, at the same time protecting honest dairymen against unscrupulous competitors. The municipal board of health was the logical body to undertake such work.

The earliest laws relating to milk dealt with chemical adulteration, skimming, watering, and the addition of preservatives. Later, laws were enacted governing sanitary conditions and prescribing limits for bacterial counts. These laws, and the methods used in enforcing them, have been changed from time to time to keep pace with advances in the sciences of sanitation and bacteriology. At the present time, practically every city of importance in this country has dairy and milk inspection. It is safe to say that no other country in the world has a market milk supply so thoroughly protected as that of the United States.

DAIRY LAWS

Existing dairy laws are many and various. The first laws were framed with only a meager knowledge of the subject, and were so worded that they were vague and cumbersome. During the last few years, much work has been done to standardize and simplify such regulations, but, in spite of this effort, many absurd rules still exist. This lack of uniformity has been the cause of much dissatisfaction among dairymen. It is not unusual for dairy farmers to be under the supervision of two, and sometimes three or four agencies. For instance, the dairyman may have to meet the requirements of his state dairy inspector, the city dairy inspector and the inspector employed by the company which purchases his milk. If the regulations of each agency vary, he encounters a number of conflicting orders which may cause bewilderment and additional expense.

The following table shows the variation in standards for market milk, between states having the highest and lowest standard for each constituent.

Constituent.	High. Per Cent.	Low. Per Cent
Butter-fat.....	3.5	3.0
Solids-not-fat.....	9.0	8.0
Total solids.....	12.5	11.0

Such a variation is, of course, without good reason. It means that milk which would be considered good, wholesome food in one state is unsalable in another. In the Appendix may be found a list of the different state chemical standards for milk.

The greatest and most perplexing variation, however, is in laws and regulations governing sanitary conditions. Here dairy farmers and milk dealers are confronted with a diversity of conflicting data and conjecture regarding bacterial counts, building construction, and so forth.

FORMULATING A MILK ORDINANCE

The milk ordinance of a community is the legal authority which gives to the people, through their Board of Health, power to supervise and control the milk supply. Three distinct phases must be covered in a suitable ordinance: first, fraud; second, disease; and third, cleanliness in the production and handling of milk.

Without a reasonable, practical, and operative ordinance, milk control officials are handicapped in their efforts to improve and safeguard the milk supply. Many ordinances are so worded that the purpose for which they are drawn cannot be secured. Such an ordinance should be repealed and a new and suitable one enacted and enforced. The welfare of a community depends greatly upon the ordinance and its enforcement.

Every ordinance should provide that the health officials be given the authority to make rules and regulations for the proper enforcement of such ordinance. This is essential. Such rules and regulations should be practical, reasonable, and clear in wording and meaning.

An adequate milk supply is essential. The Board of Health should be concerned with quantity as well as quality. Rules should not be promulgated which would result in an inadequate supply. The proper enforcement of common-sense regulations will result in a safe milk supply without serious curtailment of the quantity.

It should be the aim of the milk control officials to constantly improve the quality of the milk supply. With a suitable ordinance this may be done by adding to or changing the rules and regulations governing the production and handling of milk, without the necessity of amending the ordinance.

To help those communities that contemplate framing new ordinances, and those which are about to revise old ones, the United States Department of Agriculture has published a pamphlet containing a guide for formulating a milk ordinance. (1) This guide is a skeleton ordinance, simple, concise and short. It does not definitely fix standards as it was believed that such standards, especially for grades, should be made only after a careful study of the local milk supply. Furthermore, the "model ordinance" does not deal with minor regulations, but empowers the local health department to make rules for the proper enforcement of the ordinance.

The ordinance advocated is as follows:

FORM OF ORDINANCE

An Ordinance to Regulate the Production and Sale of Milk and Cream, and for Other Purposes

Be it ordained by the ..... of the city of .....:

Sec. 1. That for the purpose and within the meaning of this ordinance, (*a*) "milk" is the lacteal secretion obtained from the complete milking of cows; (*b*) "skimmed milk" is milk from which substantially all of the milk fat has been removed; (*c*) "certified milk" is milk produced and

handled in conformity with the "Methods and Standards for the Production and Distribution of Certified Milk," adopted by the American Association of Medical Milk Commissions, June 24, 1930, and amendments thereto, in effect at the time of production, and certified to by a milk commission constituted in compliance therewith; (*d*) "grade A milk" is milk produced from healthy cows, as determined by the tuberculin test and physical examination within not exceeding one year previously by a qualified veterinarian, from dairies that score not less than ..... on the dairy-farm score card in current use at the time by the United States Department of Agriculture, which milk shall not, at any time, contain more than ..... bacteria per cubic centimeter. All employees on Grade A farms shall be subjected to a medical examination at prescribed intervals and shall be healthy and incapable of transmitting infectious diseases; (*e*) "grade B milk" is milk produced from healthy cows, as determined by physical examination within not exceeding one year previously by a qualified veterinarian, from dairies that score not less than ..... on the dairy-farm score card in current use at the time by the United States Department of Agriculture, which milk shall not, at any time contain more than ..... bacteria per cubic centimeter; (*f*) "pasteurized milk" is milk every portion of which has been heated to, and for at least thirty minutes held at, a temperature never less than 142° F.; (*g*) "cream" is that portion of the milk, rich in milk fat, which rises to the surface of the milk on standing, or is separated from it by centrifugal force, and containing not less than ..... per cent of milk fat; (*h*) "homogenized," or "emulsified," milk or cream is milk or cream which has been subjected to the mechanical process of homogenization, or of emulsification as the case may be; (*i*) "untreated containers" are containers which either have not been subjected to moist heat at a temperature as high as 205° F. for two minutes or longer, or do not comply with such alternative requirements, to be prescribed by the regulations made pursuant to this ordinance, as may be necessary to constitute effective treatment thereof; and (*j*) "person" imports both the plural and the singular, as the case demands, and includes corporations, partnerships, societies, and associations.

When construing and enforcing the provisions of this ordinance, the act, omission, or failure of any officer, agent, or other person acting for or employed by any individual or by any corporation, partnership, society, or association, within the scope of his employment of office, shall in every case be also deemed to be the act, omission, or failure of such individual, corporation, partnership, society, or association, as well as that of such officer, agent, or other person.

Sec. 2. That no person shall sell or deliver for consumption as milk or cream or have in his possession with intent to sell or deliver for consumption as milk or cream either—

(*a*) Milk or cream to which water or any foreign substance has been added; or

(*b*) Milk containing less than .. .. per cent of milk fat or less than ..... per cent of solids not fat, or cream containing less than ..... per cent of milk fat, unless such milk or cream is plainly

and conspicuously labeled "Subnormal," together with a statement showing the actual per cent of milk fat contained therein; or

(*c*) Skimmed milk which has not been pasteurized or made from pasteurized milk, which is not labeled "Skimmed Milk"; or

(*d*) Milk or cream containing, or which has been exposed to, any disease-producing bacteria; or

(*e*) Milk or cream the container of which is labeled or branded so as to mislead or deceive the purchaser; or

(*f*) Milk or cream produced from diseased cows, or from cows during the period of 15 days preceding parturition or within such time thereafter as the milk is abnormal, or from cows which have been fed unwholesome food or have had access to contaminated water; or

(*g*) Milk or cream which falls below the requirements of grade B, as defined herein, or milk or cream which has been produced, stored, handled, or transported in any unclean or insanitary manner; or

(*h*) Milk or cream the retail, or the final, container of which does not bear a plain and conspicuous statement showing the kind and grade as herein defined; or

(*i*) Milk or cream in untreated containers; or

(*j*) Milk or cream which such person has kept at a temperature higher than 50° F.; or

(*k*) Grade B milk or cream which has not been pasteurized; or

(*l*) Homogenized milk or cream, or emulsified milk or cream, unless it is plainly and conspicuously labeled "Homogenized," or "Emulsified," as the same may be; or

(*m*) Milk which has had the cream line increased by artificial means.

(*n*) Milk or cream made by combining milk powder and water, with or without the addition of butter or butterfat, unless it is plainly labeled "Remade" or "Reconstituted."

Sec. 3. That nothing in this ordinance shall be construed to prohibit the sale, when labeled so as to show its true character, of either (*a*) sour milk or sour cream; or (*b*) buttermilk, or any similar product made from pasteurized milk or cream; or (*c*) modified milk if made from milk or cream equal at least to grade B.

Sec. 4. That no person shall sell or deliver, or have in his possession with intent to sell or deliver, for consumption as milk or cream, any milk or cream without a permit from the Board of Health of .....

Sec. 5. That the Board of Health of ..... is authorized to make such regulations, from time to time, as are necessary for the efficient execution of the provisions of this ordinance, and to issue permits to sell and deliver milk or cream in ..... The Board of Health, after affording the permittee an opportunity for a hearing, may suspend or revoke any permit issued by it under this ordinance whenever it shall determine that the permittee has violated any of the provisions of this ordinance or of the regulations made hereunder, and, without affording such opportunity, may suspend such a permit temporarily whenever it deems necessary.

Sec. 6. That the Board of Health of ....., its members, officers, and agents, shall have access at all reasonable times to any dairy or any other place where milk or cream is produced for sale;

to any wagon, truck, train, car, warehouse, or station in which milk or cream for sale is being transported or is being held for transportation or delivery; and to all establishments, plants, depots, or stores where milk or cream is kept or stored for sale. Any person who hinders or prevents such access shall be guilty of a violation of this ordinance.

Sec. 7. That any producer, handler, or seller of milk or cream, whether principal, agent, or employee, who, on demand, refuses to sell or deliver a sample, not to exceed one pint, of milk or cream in his possession to any official designated by the Board of Health to collect samples, shall be guilty of a violation of this ordinance.

Sec. 8. That any person violating any of the provisions of this ordinance, on conviction by any court of competent jurisdiction, shall be punished by a fine of not more than ..... dollars, or by imprisonment of not more than ....., or by both such fine and imprisonment, in the discretion of the court; and for each subsequent offense, and conviction thereof, shall be punished by a fine of not more than ..... dollars, or by imprisonment of not more than ....., or by both such fine and imprisonment, in the discretion of the court.

ESSENTIAL REGULATIONS

Sometimes health departments prefer to incorporate definite regulations in their ordinances. Even if they do not, they should formulate such regulations as will properly protect the milk supply. Essential rules should be made which may be expanded to meet all conditions.

At the meeting of the International Association of Dairy and Milk Inspectors, held in Washington, D. C., October 15–17, 1917, the Committee on Rules and Regulations Necessary for Securing a Clean and Safe Milk Supply made a report, the gist of which is given below.

This report was unanimously adopted by the association and represents the best thought and opinion of those in closest touch with milk and dairy control work.

RULES

From the report of the Committee on Rules and Regulations Necessary for Securing a Clean and Safe Milk Supply, Acting for the International Association of Dairy and Milk Inspectors.

Rules for Production

1. Every dairy producing market milk should be licensed by the city or state, so that a complete record may be kept.

2. Cattle should be healthy, as determined by the tuberculin test and a physical examination by a competent veterinarian. They should be tested at least once a year, and where reactors are found they should be removed and a retest conducted within six months. If the milk is to be properly pasteurized, the physical examination may suffice but the committee wished to affirm its belief in the economic and sani-

tary importance of the tuberculin test. Milk should be unsalable from cows within 15 days before calving and as long thereafter as the milk is abnormal.

3. All persons engaged in the production of milk should be free from communicable disease and from contact with any such disease. Medical examination of employees is advised where feasible.

4. Every operator of a dairy farm should, within 24 hours, notify the health department having jurisdiction over his milk, of the presence of any communicable disease on his farm or among the milk handlers.

5. The water supply on premises where milk is produced should be abundant and protected from contamination. It should be free from any disease-producing organisms.

6. Privies on dairy farms should be fly-proof, and provided with a water-tight receptacle for the excreta. The excreta should be removed frequently and buried at least two feet deep, where they cannot contaminate the water supply.

7. Cows should be clean. They should be free from accumulations of dirt, and their udders and flanks should be wiped with a clean, damp cloth just previous to milking.

8. Milking should be done with clean, dry hands or with a properly treated milking machine. Milkers should milk in clean clothing.

9. Some type of small-top milking pail should be used.

10. Milk should be removed as soon as drawn, to a clean place, strained through a new cotton or other clean, efficient strainer, and be cooled within one hour to 50° F. or less. It should be kept covered and be held below 50° F. at all times.

11. All utensils which come in contact with milk should be thoroughly washed and treated for at least five minutes with steam or boiling water. They should be kept inverted and protected from contamination until used.

Rules for Transportation

1. During transportation from farm to city, milk should be kept free from contamination and should be held at or below 50° F.

Rules for Handling and Delivery

1. All persons engaged in the sale of milk should be licensed by the state or city in which they conduct their business.

2. All persons engaged in the handling or delivery of milk should be free from communicable diseases and from contact with such diseases. The operator of any milk plant should immediately advise the health department of the presence of any communicable diseases among his employees or in their homes.

3. The water supply of all establishments where milk is handled should be pure and free from disease-producing organisms.

4. Proper toilet facilities should be provided for all employees, together with wash bowl, soap and towel for the cleansing of hands.

5. Where pasteurization is performed, a temperature of approxi-

mately 145°, and never less than 142° F., should be maintained for at least thirty minutes.

6. All machinery, cans, bottles, etc., with which milk comes in contact should be thoroughly washed and treated with steam or boiling water; and they should be protected from contamination until used.

7. At all times, except during pasteurization, milk should be held at or below 50° F. until delivered to the consumer.

8. Milk should be delivered to the consumer only in bottles or sealed cans.

APPROPRIATION FOR MILK AND DAIRY INSPECTION

The cost of dairy inspection varies according to a number of factors, such as, number of farms to be inspected; distance of farms from city;

FIG. 23.—A laboratory for milk analysis.

accessibility of farms; sanitary condition of farms; frequency of inspection; degree of laboratory control, etc. The influence of the first three factors mentioned is obvious. It is also true that farms in bad sanitary condition need frequent and thorough inspection, together with careful laboratory examinations. The exact cost for any municipality cannot be accurately predicted. It will usually run from 5 cents to 10 cents per capita population per year. Quite generally the per capita cost will be larger in small cities and towns for an adequate full-time control

system. Associations of adjacent towns, and county control, can be used economically.

LABORATORY FACILITIES FOR MILK ANALYSIS

In milk-control work, it is essential that there be sufficient laboratory facilities for chemical and bacterial examinations of milk. Bacterial counts indicate milk of doubtful quality and serve to guide the dairy inspector to those farms or city plants which need attention. Chemical analyses are required to see that milk comes up to the standard and is not adulterated. A list of laboratory equipment and supplies of the average small city is given in the Appendix.

ORGANIZATION OF INSPECTION FORCE

In small towns where only one or two inspectors are employed, the organization is very simple. Usually the inspectors report directly to the city health officer. Laboratory examinations are also conducted by the inspector.

Where large forces are employed, a more complex organization exists. Such an organization includes a chief inspector, supervising inspectors, farm inspectors, city inspectors, laboratory workers and collectors of samples. A practical scheme for a large organization is as follows:

- Mayor
  - Health Officer or Dept. of Public Health or Welfare
    - Chief Milk Inspector
      - Supervising Country Inspectors
        - Dairy Farm Inspectors
        - Country Plant Inspectors
      - Supervising City Inspectors
        - Inspectors at R.R. Terminals
        - Inspectors of City Plants
        - Inspectors of Stores
        - Collectors of Samples
      - Laboratory Chief
        - Chemists
        - Bacteriologists

The chief inspector is responsible for carrying out policies and seeing that the supervising inspectors keep in close touch with the central office. He also recommends the revocation of permits and helps in prosecuting court cases.

The supervising inspectors are assigned a certain area or group of plants, and must see that the inspectors under them do their work efficiently. They are responsible for all work in their territory.

There are various deviations from the plan outlined. In some cities the inspection forces and the laboratory forces are entirely separate. In

such cases the heads of the two branches report independently to the health officer who correlates their activities.

INSPECTION IN SMALL TOWNS

In small towns the per capita assessment to maintain efficient milk inspection would be too great. Neither would there be sufficient work to keep an inspector busy all the time. In several such cases, the situation has been met by the combination of a number of small villages, whereby a competent inspector is hired. His salary and expenses are met by joint appropriations, and he inspects the supply of each village. One of the most successful of these organizations is the Milk Inspection Association of the Oranges, in New Jersey.

Often, when a town does not employ a milk inspector, the State Board of Health or State Dairy Commission will inspect the supply occasionally. Sometimes a representative of the state will be designated as an "agent," and will be stationed permanently in one town. The town may or may not pay part of his salary.

QUALIFICATIONS OF DAIRY INSPECTORS

In the past, much injury has been done to the dairy industry and to the cause of dairy inspection as well, by the employment of incompetent inspectors. During the last few years, there has been a decided improvement along this line.

Dairy inspectors should possess tact, perseverance, knowledge, energy and courage. The bullying dictatorial type may enforce certain rules temporarily; but the greatest good and more lasting results are secured by the inspector who uses reason as a flame to light the path. For that reason, agricultural graduates and men who have lived and worked on farms are particularly useful; they can understand the farmers' problems, and offer practicable suggestions. The International Association of Dairy and Milk Inspectors appointed a committee to outline the qualifications of inspectors. The committee report (3) covered investigations in thirty-one states and one hundred and two cities. The conditions disclosed led to the following recommendations:

1. Cities and States should strive to employ only men who can devote their entire time to dairy and milk inspection.
2. No dairy or milk inspectors should be employed who derive any private income from the persons with whom they deal in their inspection work.
3. Salaries should be paid to dairy and milk inspectors commensurate

with the training and experience necessary for properly performing the work.

4. Dairy and milk inspectors should be protected by civil service laws against removal except for cause.

5. Civil-service requirements should recognize the fact that special education and training are not only desirable but necessary in a candidate for appointment.

6. Dairy and milk inspectors should be agricultural college graduates or should have at least attended such an institution, or institutions of similar rank, long enough to have acquired a working knowledge of dairy sanitation, bacteriology and chemistry.

7. It is very desirable that inspectors should have had practical experience in at least one branch of the dairy business, so that they are familiar with trade practices and the problems with which they will be constantly confronted.

MILK INSPECTORS' ASSOCIATIONS

For the purpose of unifying inspection methods and interchanging experience on mutual problems, dairy and milk inspectors have formed State and International Associations. The state organization in Massachusetts, with a membership covering practically the entire state, is a splendid example of such cooperation. Meetings are held at least once a year and many valuable papers and discussions are included.

The International Association of Dairy and Milk Inspectors was organized by nine men, Oct. 16, 1911, in Milwaukee, Wis. Its object is "to develop uniform and efficient inspection of dairy farms, milk establishments, milk and milk products; and to place the inspection of the same in the hands of men who have a thorough knowledge of dairy work." From this humble beginning, the Association has made a remarkable growth.

EDUCATIONAL FEATURES OF DAIRY INSPECTION

Modern dairy inspection includes educational work with milk producers, milk dealers, and consumers. Of course, sanitary instruction is the first aim and duty of the inspection force. Aside from this, help may be given farmers along economic lines, such as better buildings, better cattle, better feeding practices, etc. An inspector, by giving such assistance, can often procure desired sanitary results by gaining the dairymen's good will and confidence.

Milk Contests.—One of the best educational means of securing better milk is the competitive milk contest. (4) In such contests, dairymen producing milk for a certain city are allowed to submit samples of their product. The samples must all be produced on the same date, and are

delivered to the officials in charge, to be placed in cold storage. When all samples are in, the judges rate them on the basis of bacterial content, chemical composition, flavor and odor, acidity, sediment, and appearance. The method of scoring milk and cream will be discussed in another chapter.

Prizes are awarded the dairymen obtaining the highest scores. These prizes are usually donated by the Chamber of Commerce or other civic organization. Meetings are held where producers, distributors and consumers are brought together for the discussion of mutual prob-

Fig. 24.—Samples entered in a milk and cream contest.

lems. Such meetings usually result in much better understanding between all parties concerned.

Milk-contest Plan for Grading Milk.—Several cities, chiefly on the Pacific Coast, use milk scoring to establish the standing of the dairymen. Samples are taken at intervals from the milk being delivered, as in ordinary inspection routine. The laboratory keeps its regular record of bacterial counts, fats and solids. At least four times a year samples are taken to be scored for flavor and odor, sediment, acidity and appearance. At the end of the year, all of the records are combined into a total score on the milk score card. These scores are published, divided into groups, such as certified, raw, and pasteurized. This plan has aided materially in improving milk supplies. Of course, efficient dairy inspection has accompanied the milk scoring, but much of the success can be attributed to the influence of the contests.

REFERENCES

(1) Inspection of Milk Supplies, U. S. Dept. Agri., Circ. 276.
(2) Seventh Annual Report, International Association of Dairy and Milk Inspectors, 1918.
(3) Fifth Annual Report, International Association of Dairy and Milk Inspectors, 1916.
(4) How to Conduct Milk and Cream Contests, U. S. Dept. Agri., Circ. 384.
U. S. Dept. Agri., Health Officer Letters Nos. 23, 46, 50.
U. S. Dept. Agri., Leaflet, Legal Standards for Dairy Products.
Schorer, Milk Regulations in the U. S. Jour. Am. Public Health Assn., Vol. 1, No. 11.

CHAPTER VIII

DAIRY FARM INSPECTION

Sanitary inspection at the source of a milk supply is of the utmost importance, for dirty milk can never be made as wholesome as clean milk. It can be improved by various processes, such as pasteurization; but it can never be made so desirable as milk produced and handled under sanitary precautions. If the milk is to be used raw, inspection is obviously necessary. Pasteurization should not be used as an excuse for dirty methods; inspection at the farm is equally essential in the case of milk which is to be pasteurized.

Health officers of 323 cities in the United States were interrogated as to the value of farm inspection. Replies from 309 of them were decidedly in favor of inspection, while only 14 were in the negative. Thus, the overwhelming experience of men engaged in milk control work is in favor of sanitary inspection at the farms. This does not mean that farm inspection is the only course to pursue. Bacteriological and chemical control should be correlated with field inspection, so that one serves as a guide to the other.

Inspection is extremely desirable from an educational standpoint. If bacterial counts are high, the inspector can go immediately to the farm at fault, and point out insanitary conditions. Thus, the farmer is shown definitely how to comply with the regulations. Should a farmer receive notice from the health department of a high bacterial count, he would be at a loss to know how to improve conditions, unless he had the advice of a sanitary expert.

Inspection of dairy farms will furnish evidence of disease in dairy cows and milk handlers. It will supply information regarding water supply and sewage disposal—both important public health matters. It will enable the official to judge, by personal acquaintance with the dairymen, the best means of accomplishing hoped-for results. By means of it he may be able to accomplish by persuasion what he might otherwise fail to bring about, except by most drastic methods.

SCORE-CARD SYSTEM OF DAIRY INSPECTION (1)

In the early development of dairy farm inspection, it was realized that it would be necessary to devise some system to insure uniformity of

inspection. Originally, the milk control official visited the dairies, made comments, and took notes for future reference. There was no system of comparison between dairies and no method of determining their sanitary rating or standing in the community.

The first score card in which a numerical rating was given was developed in 1904. During the next three years, a committee from the official Dairy Instructors' Association (now the American Dairy Science Association) studied the situation and evolved the general outline of the card now used by the Bureau of Dairy Industry, and known as the official score card. The merits of this card were recognized from the first, and its use has spread among milk-control officials until, at the present time, many cities, state departments, and educational institutions carry on inspection with the dairy farm score card.

There is no doubt that the score card is a great factor in improving a milk supply and has a place of equal importance with bacterial control.

The score card promises uniformity of inspection. The inspector has before him a printed list of points to consider. This list comprises factors which tend to obtain better sanitary conditions in the production, handling and transportation of milk. The use of this card insures the same kind of treatment for all dairymen.

It promotes friendly rivalry among dairymen. Since each dairyman in a community occupies the same status as regards inspection, the numerical rating establishes the position of each one in comparison with his fellow dairymen. It tells him his standing in the community in relation to sanitary milk supply, and it causes the ambitious dairyman to try to excel. This point alone means better sanitary conditions surrounding the production and handling of the milk supply.

The use of the score card is educational. Most dairymen want to deliver a high-grade product. The score card teaches the points of most importance, and the producer learns from his score which factors he must emphasize in bettering his supply.

The dairy farm score card systematizes the work of dairy inspection, teaches sanitary milk production to the dairymen, develops healthy competition among producers, interests consumers in demanding better sanitary conditions in dairies, and results in a cleaner, safer, purer milk supply.

The essential principle of the score-card system is to assign a certain mathematical rating for each condition which may affect the sanitary condition of the milk produced. By avoiding large allotments to general features and subdividing each feature into small units, there is less chance for inaccuracy through deviations of personal judgment. For instance, if a score of 25 was allotted to stables, different inspectors might

vary 5 to 10 points in judgment; but if this 25 points is divided into items of 1 or 2 points each, variation will be slight.

The score card contains 100 points, 40 for equipment and 60 for methods. The total, 100, represents ideal conditions. The score card is not a system of absolute regulations, but rates a dairy as the inspector finds it, giving credits for good conditions, and cuts for poor ones.

SCORE CARD VERSUS BACTERIAL COUNT

The dairy farm score card has been a potent factor in improving city milk supplies. There is abundant testimony to this effect. In spite of this, there has been some criticism of the score card which is apparently due to a misunderstanding of its real function. The commonest criticism is that the score card will not invariably indicate the bacterial count in milk from individual farms. The score card was not intended for this purpose; it was devised to point out certain factors which have a bearing on the sanitary conditions under which milk is produced. Obviously, ratings on health of cattle, purity of water supplies, feed for cattle, ventilation and air space in barns, and such items, have no decided influence on the numerical bacterial count; but they are important because they indicate possible sources of dangerous infection.

It is true that some small communities, without laboratory facilities, have used the score card as the sole means of judging milk purity. In doing this, some individual cases of injustice have probably occurred; for it is possible for a trained man to produce high quality milk by exercising extreme care even amid poor surroundings. In dairy inspection, however, we are not dealing with the exceptional man; but with the average man. Years of work in many cities have demonstrated that, on the average, high-scoring dairies produce high-class milk, and vice versa.

Table 22 shows the result of work done by the U. S. Department of Agriculture covering the milk supplies of two cities:

TABLE 22

Dairy Farm Score.	Number of Samples.	Average Bacterial Count per c.c.
40– 49	7	2,730,857
50– 59	31	1,311,951
60– 69	59	1,125,153
70– 79	128	234,880
80– 89	27	145,700
90–100	3	23,000

The figures show the intimate relation between general sanitation and bacterial count. Other workers in the actual field of dairy inspection have reported corroborative results.

In spite of these relations, it is well to restate the fact that the score card is primarily intended for sanitary surveys, without direct bearing on total bacterial count.

THE DAIRY FARM SCORE CARD

Reproductions of the obverse and the reverse of the score card for dairy farms will be found on pages 105 and 106.

The numerical ratings are divided into two columns, headed "Equipment" and "Methods." The greatest credit (60 points out of 100) is given to methods, because cleanly methods are of greater importance than equipment in the production of clean milk.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF DAIRY INDUSTRY

SANITARY INSPECTION OF DAIRY FARMS

SCORE CARD

Indorsed by the American Dairy Science Association

Owner or lessee of farm.....

P. O. address.....State.....

Total number of cows.....Number milking.....

Gallons of milk produced daily.....

Product is sold by producer in families, hotels, restaurants, stores, to.....dealer.

For milk supply of.....

Permit No.....Date of Inspection....., 19

REMARKS:.....

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(*Signed*).....

Inspector.

Equipment.	Score. Perfect.	Allowed.
COWS.		
Health	6	
Apparently in good health	1	
If tested with tuberculin within a year and no tuberculosis is found, or if tested within six months and all reacting animals removed	5	
(If tested within a year and reacting animals are found and removed, 3)		
Food (clean and wholesome)	1	
Water (clean and fresh)	1	
STABLES		
Location of stable	2	
Well drained	1	
Free from contaminating surroundings	1	
Construction of stable	4	
Tight, sound floor and proper gutter	2	
Smooth, tight walls and ceiling	1	
Proper stall, tie, and manger	1	
Provision for light: Four sq. ft. of glass per cow	4	
(Three sq. ft., 3; 2 sq. ft, 2; 1 sq. ft., 1. Deduct for uneven distribution)		
Bedding	1	
Ventilation	7	
Provision for fresh air, controllable flue system	3	
(Windows hinged at bottom, 1.5; sliding windows, 1; other openings, 0.5)		
Cubic feet of space per cow, 500 ft	3	
(Less than 500 ft., 2; less than 400 ft., 1; less than 300 ft., 0)		
Provision for controlling temperature	1	
UTENSILS		
Construction and condition of utensils	1	
Water for cleaning	1	
(Clean, convenient, and abundant)		
Small-top milking pail	5	
Milk cooler	1	
Clean milking suits	1	
MILK ROOM OR MILK HOUSE		
Location: Free from contaminating surroundings	1	
Construction of milk room	2	
Floor, walls, and ceilings	1	
Light, ventilation, screens	1	
Separate rooms for washing utensils and handling milk	1	
Facilities for steam	1	
(Hot water, 0.5)		
Total	40	

Methods.	Score. Perfect.	Allowed.
COWS.		
Clean	8	
(Free from visible dirt, 6)		
STABLES		
Cleanliness of stables	6	
Floor	2	
Walls	1	
Ceilings and ledges	1	
Mangers and partitions	1	
Windows	1	
Stable air at milking time	5	
Freedom from dust	3	
Freedom from odors	2	
Cleanliness of bedding	1	
Barnyard	2	
Clean	1	
Well drained	1	
Removal of manure daily to 50 feet from stable	2	
MILK ROOM OR MILK HOUSE		
Cleanliness of milk room	3	
UTENSILS AND MILKING		
Care and cleanliness of utensils	8	
Thoroughly washed	2	
Treated with steam for 15 minutes	3	
(Placed over steam jet, or scalded with boiling water, 2)		
Protected from contamination	3	
Cleanliness of milking	9	
Clean, dry hands	3	
Udders washed and wiped	6	
(Udders cleaned with moist cloth, 4; cleaned with dry cloth or brush at least 15 minutes before milking, 1)		
HANDLING THE MILK		
Cleanliness of attendants in milk room	2	
Milk removed immediately from stable without pouring from pail	2	
Cooled immediately after milking each cow	2	
Cooled below 50° F	5	
(51° to 55°, 4; 56° to 60°, 2)		
Stored below 50° F	3	
(51° to 55°, 2; 56° to 60°, 1)		
Transportation below 50° F	2	
(51° to 55°, 1.5; 56° to 60°, 1)		
(If delivered twice a day, allow perfect score for storage and transportation)		
Total	60	

Equipment ..... + Methods ..... = ... Final Score

Note 1.—If any exceptionally filthy condition is found, particularly dirty utensils, the total score may be further limited.

Note 2.—If the water is exposed to dangerous contamination, or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

USING THE FARM SCORE CARD

The following instructions for using the dairy farm score card are taken from Circular 276, U. S. Department of Agriculture. (1) They have been somewhat modified to clarify certain points and enlarge others. Good judgment and careful thought are necessary in making the score; conditions as they actually exist must be weighed against ideal conditions. By considering whether items are quarter perfect, half perfect, etc., intelligent ratings can be given. Expert inspectors, especially at high-class dairies, will often make deductions as fine as one-tenth of a point.

Equipment.—*Health of Cows.*—Every individual cow in a herd should be well nourished, sound, and healthy. Physical disability of any description, such as enlarged glands, lumpy jaw, running sores, inflamed or defective udder or teats, makes a perfect score impossible. A deduction should be made in the score in proportion to the number and importance of the defects found. In some instances, the especially dangerous condition of a single cow, from the standpoint of healthful milk, may justify a score of zero for the entire herd or dairy.

The methods to be employed and the desirability of obtaining definite knowledge regarding the existence or non-existence of tuberculosis are indicated on the score card. If the herd has been tested with tuberculin within the year and no tuberculosis found, or within six months and all reacting animals removed, the score will be perfect, and 5 points are allowed. If tested within the year, but not within six months, and reacting animals are found and removed, 3 points are allowed.

Feed.—Feed should be free from mustiness or offensive decomposition. Decaying silage, fermenting brewers' grains or distillery slops, or moldy or dusty hay should reduce the score. The improbability that the by-products of distilleries and breweries will be fed properly has led many authorities to condemn feeding distillery swill, and even wet brewers' grain. Under ordinary circumstances, when these by-products are fed while moist, an additional cut should be made under the item "stable air at milking time."

Sanitary inspection does not concern itself with balanced rations and the economical phases of dairying—only with clean, wholesome feed.

Water.—Drinking water for cows should be fresh and uncontaminated. Danger of pollution from the drainage from barnyard, manure pile, or privy will reduce the score, as should unprotected wells and stagnant pools. Where the water tank, trough, or other receptacle is not kept clean, the score cannot be perfect. The water supply should be so convenient to the stable as to make it unnecessary to expose the cows to

extreme cold or severe storms. The supply should be so abundant as to remove any doubt as to the ability of each animal to satisfy its thirst.

Location and Construction of Stable.—Cow stables should have a well-drained location. This does not relate to construction; a score should be reduced when the site is not drained, as when a barn is built in a depression or on level land which is not underdrained. The stables should also be free from contaminating surroundings. Horse stables, pigeons, chicken coops, stagnant water, privies, etc., when near enough to pollute the stable air, should reduce the score. Provision is made in another place for a reduction of the rating when the barnyard is unclean and poorly drained, though, when conditions are exceptionally bad, an additional cut can be made here. A yard may be so very dirty as to be a contaminating adjunct of a stable.

FIG. 25.—Exterior of a modern, sanitary dairy stable. Note adequate provision for light and ventilation.

The stable should have a tight, sound floor, incapable of absorbing liquids to any appreciable extent. An earth floor is undesirable. Back of the cows should be a gutter (preferably concrete) of sufficient capacity to hold the droppings and keep them from soiling the cows. A gutter 16 inches wide and 8 inches deep is recommended. It should have sufficient incline to drain readily, unless the liquid manure is taken up by absorbents. Some form of swing stanchion is the best kind of tie, as it allows freedom and keeps the animals out of the gutter. The manger should be as simple as possible; cumbersome constructions collect dust, prevent circulation of air, and are difficult to keep clean. When of wood, the angles, joints, and cracks are especially liable to be dirty, and in case of outbreaks of tuberculosis disinfection is difficult. A concrete trough or a smooth manger or feeding floor answers the purpose and is given the highest score. Walls and ceilings should be smooth and tight; deductions in the score should be made for exposed crossbeams, bridging, braces, shelves, niches, ledges and anything which might harbor dust.

Provision for Light.—An abundance of light destroys bacteria, promotes the health of animals, and facilitates keeping things clean. In scoring for this item consider the number of stanchions rather than the number of cows which happen to be in the barn at the time of inspection. The score is for the means by which the light is obtained, as well as the amount. The perfect means of lighting the stable, as of lighting the residence, is by glass windows, and a perfect score can be obtained only where there are 4 square feet of glass per stanchion. Sometimes a stable is well lighted on one side or at one end; in such a case a deduction should be made from the score for " uneven distribution."

Bedding.—Cows should be bedded so as to promote their comfort, especially where the floor is of cement, but the bedding should not be of

FIG. 26.—Interior of a good dairy stable. It has smooth walls, cleanable floors and capacious gutters.

such nature as to contaminate the milk. Clean shavings are highly advantageous from the sanitary standpoint. Loam, sand and dried muck are not to be commended, on account of the great difficulty in keeping the dust out of the hair of the animals. Horse manure should not be used for bedding. Dusty or moldy hay or straw will not give a perfect score. Dairies of superior quality have been seen where the cows were bedded liberally with straw previous to milking, so much being used that the milkers had to kick it to one side in order to make a place to sit down and milk. Such a procedure would probably result in filling the air with bacteria-laden dust and militate against clean milk. The sufficiency of bedding in quantity is scored on the side of equipment; the cleanliness of the bedding and its proper use on the side of methods.

Ventilation (2).—The item of ventilation on the score card is subdivided into three topics. The first relates exclusively to the opportunity for providing pure air; the second to the prevention of excess of impure air from overcrowding of animals; the third to the efficiency of the method used for conserving animal heat as needed and for maintaining a proper temperature. The nearer any system of removing impure air and admitting fresh air approaches to being automatic the better it is. No system is absolutely automatic; but to be scored as perfect it should have some kind of controllable flues or their equivalent. The King system is the most generally known system of ventilation and is probably the best system when properly installed, in working

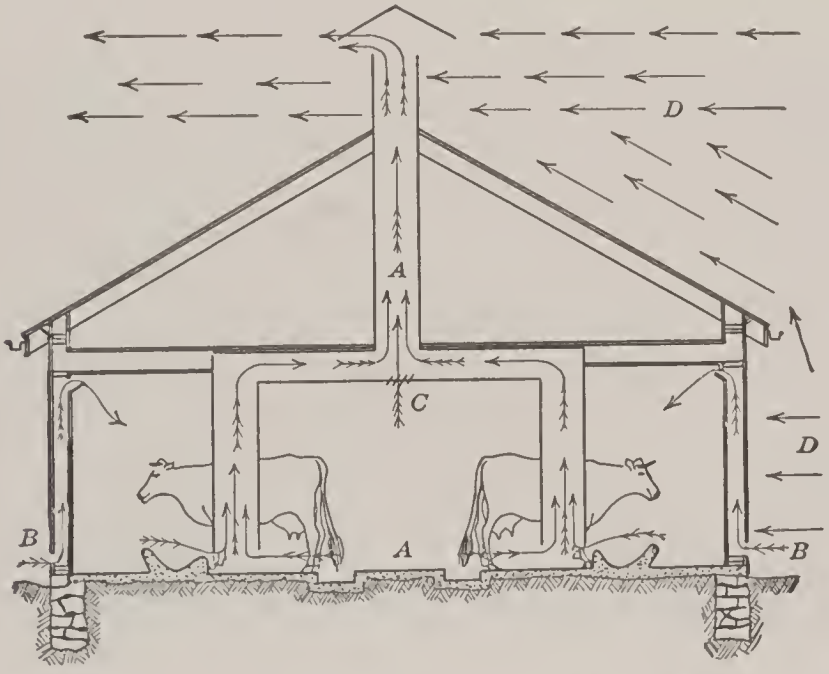

FIG. 27.—Section of dairy stable showing action of the wind at *DD*, forcing air into the stable by direct pressure at *BB* and out of it by suction at top of ventilating shaft *AA*. At *C* is a ceiling register to be opened only when stable is too warm or when draft is too feeble. From "Ventilation for Dwellings, Rural Schools and Stables," by F. H. King. Reprinted by permission.

order, and with sufficient capacity for the number of stanchions in the stable. Professor King says: "There should be not less than 30 square inches per head when the outlet has a height of 30 feet above the ceiling of the stable." This duct should work on the principle of a chimney, and the higher it is the greater the draft or suction. Consequently, as this outlet is of less height, the cross-section area should be greater; while if it is higher, the area may be less. A 20-foot outtake would require about 36 square inches per stanchion, according to Professor King.

The system of ventilation by windows swinging in at the top is an excellent one, though not quite equal to the King system, because the possibility of negligence is increased. A sliding window will receive much less credit; while hay holes, large spaces in the loft, and even cracks in the boarding on the side might receive some slight consideration from the standpoint of admission of pure air.

A stable in which the cows have been kept overnight should be comfortable in the morning, without disagreeable animal odors. The item relating to the control of stable temperature refers to the possibility of so regulating the ventilating system as to secure the comfort of the cows. For instance, a stable whose supply of pure air comes entirely through wide cracks in the boarding, admitting drafts on the cows, would score nothing on this item. Dependence upon sliding windows might also reduce the score, because they frequently admit air in drafts on the cows' backs. A stable having a roof of the monitor type would sometimes be uncomfortably cold under northern conditions by allowing too much heat from the cows' bodies to escape, and therefore such a roof would call for a reduction of the score, while the same condition in the South might be rated perfect.

An overcrowded barn produces discomfort, is hard to keep clean and usually contains impure air. A proper amount of space per animal to receive a perfect score is considered to be not less than 500 cubic feet. In scoring for cubic feet of air space, consider the number of stalls rather than the number of cows which happen to be present at the time of inspection. A stable having 50 stanchions with 15,000 cubic feet of space should be regarded as having 300 cubic feet per cow. An excessive amount of space for each animal dissipates the heat from the cows' bodies and may be as bad as overcrowding. Under northern conditions, a reduction should be made in the score for "controlling the temperature" if the cubic space per cow exceeds 1000 feet.

Professor King, in his book on ventilation, frequently qualifies his statements by such clauses as "in cold climates." Through eastern North Carolina, South Carolina, Georgia, the Gulf States, two-thirds of Texas, southern New Mexico, southern Arizona, and the western slope of the Pacific Coast, runs an isothermal line showing 10° F. below zero as the lowest temperature ever recorded during a period of about thirty-eight years. This line somewhat generally marks an average mean temperature of about 40° F. for January, the coldest month. Below this line the temperature is higher. In most of the section below this line, however, occasional chilly winds and storms call for protection of animals, and therefore some means of ventilation—a fact which is too frequently overlooked by many milk producers in portions of the South

and on the Pacific Coast. The particular phase of ventilation which demands extreme conservation of animal heat is a negligible affair in this southern belt.

The stable should be scored for the way in which it appears to be adapted to secure results when those results are needed, and not merely on conditions at the time of the inspector's visit. For example, a stable without means of ventilation should score zero, even in summer when it is empty, the cows being in the pasture.

Utensils.—Utensils should be of metal, with as few seams as possible, Seams which are unavoidable should be flushed smooth with solder. Rusty and battered ware should not be used. Wire-gauze strainers should be avoided, also strainers which are complicated or have inaccessible parts that are hard to clean. Small-top milk pails should be used, as they keep out dirt and do much to promote clean milk. The water supply for washing utensils should be clean, abundant, and convenient; the chances are that cleansing will not be thorough when the water supply is meager or inconvenient. Impure water may convey undesirable bacteria to the utensils, which in turn will contaminate the milk; hence, shallow wells receiving surface drainage are to be regarded with suspicion. No water from wells where seepage from house wastes or barnyard is possible should come in contact with milk utensils.

Milkers should wear clean suits used only for milking and stored in a clean place when not in use. A milk cooler should be found in every milk room, as well as facilities for an abundance of hot water or steam. Plenty of steam for steaming utensils is the perfect arrangement; but an abundance of hot water which can be used while it is at a boiling heat is a good substitute.

The word " cooler " means one of the various appliances for passing milk over a cool surface. A tank in the milk house is not a " cooler," but it is better than nothing and will be serviceable, especially when milk is sold by the can, and might be allowed a quarter point.

Milk House.—Every dairy should have a milk house or milk room (3) fitted especially for the use to which it is to be put, in which milk can be strained, cooled, bottled or canned, and stored, and in which utensils can be washed and cared for. If possible, the washing of utensils and the handling of milk should be done in different rooms. The milk house, if attached to the barn, should have an independent outside entrance; if entered from the barn it should be through a well-ventilated passageway with self-closing doors at each end, only one of which can be open at a time. The milk house or room should not be near the hog-pen, manure pile, privy, or anything that might contaminate the air. The milk room should be light, well ventilated, and screened. Flies should

never have access to milk or utensils. The floor should be smooth and of concrete, sloping so as to give good drainage; the edge should be rounded to prevent angles for collecting and harboring dirt. The walls and ceiling should be smooth and tight; concrete or tile wainscoting is desirable. Dark corners or inaccessible places should be avoided. Where the milk house has several rooms, the score should represent the average conditions, giving especial consideration to the room in which the milk is handled. Glass windows, having an area of at least 10 per cent of the floor space, should be provided.

When there is a room in the stable where the milk is poured from the milk pails to a carrier can, that room should be considered a part of the milk house, for purposes of scoring.

FIG. 28.—Interior of milk house showing cooler and bottling machine.

Methods.—*Cleanliness of Cows.*—Cows are considered clean and entitled to perfect score when carefully groomed, and when the long hairs on the flanks and udders are clipped. Dust on backs reduces the score 1 point; large, easily visible particles of manure or mud on sides, tails, or udders, another point; and long hairs on udders, still another.

Cleanliness of Stable.—Stable floors should be kept clean by frequent careful sweeping and washing. Walls should be free from manure. Joists, brackets, braces, tops of stanchions, partitions, ledges, and ceilings should be clean and free from dust and cobwebs. The inspector should carefully examine all of the places named for dust, and make deductions when it is found. Mangers should be clean; there should be no dirt or fermenting feed in cracks and corners. Whitewash should be freely applied on walls, ceilings, partitions, etc. Windows should be clean. In scoring a "certified" or high-class dairy it is frequently

necessary to make deductions of small fractions. The inspector should be extremely cautious about scoring any item absolutely perfect from the standpoint of cleanliness.

Air in Stable.—The stable air should be free from dust and odors at time of milking. The air may be contaminated by lack of ventilation, by horses in the stable, by hogs in the basement, by manure in a cellar, by feeding silage or dusty fodder just before milking, by dusty bedding, by feeding distillery swill or wet brewers' grains, and in other ways. When inspectors cannot be present at the time of milking, a reasonably accurate estimate of conditions can be reached by general appearances and by questioning the person in attendance as to time and manner of feeding, etc. When a dairy is scored several times a year, the inspector will soon get a just idea of conditions.

Barnyard and Manure.—The manure should be removed daily from the stable, to such a distance (not in the yard) as to preclude the chance

FIG. 29.—Removal of manure from barn to field daily. A sanitary and economical method.

of odors getting back to the milk. There should be no accumulations of manure in the stable yard, which should be kept clean and reasonably dry in order to merit a perfect score. Where conditions are favorable, the ideal way is to remove the manure daily to the field; this will often prove an actual economy in conservation of plant food.

Cleanliness of Milk Room.—Where the milk house has several rooms, the score for cleanliness must be based largely on the general conditions. If there is a room in the barn where milk is poured from the pail to the can, that room should be regarded as a part of the milk house. But especial attention should be paid to the cleanliness of the room in which the milk is handled. This room should be used for no other purposes than cooling, canning, bottling, or storing milk; if it is used for general storage purposes or for anything but handling milk, the score should be materially reduced. A high standard of cleanliness

should be maintained in every part of the floor, walls, and ceiling of the milk room. When milk is stored or cooled in a tank, bad odors or foul water will reduce the score. In some localities there is a tendency to introduce gasoline engines for power; and where these are located in the milk room, unless there is evidence of exceptional painstaking, the liability to odors is such that they should cause a reduction in the score.

Cleaning Utensils.—All utensils should be clean on superficial inspection; no dirt should be found in seams or places difficult of access. After the utensils are washed they should be scalded with boiling water,

FIG. 30.—Milker washing his hands after milking each cow.

steamed, or treated with chemicals. The ordinary equipment for heating water does not usually provide it in sufficient quantities and of sufficient heat to thoroughly treat the utensils.

The utensils, after being washed and treated, should be inverted in pure air to drain and dry. If allowed to remain upright, more or less dust may fall into them. Where a steam cabinet is used, a perfect score can be allowed if the utensils remain therein until used.

Milking.—Methods of milking should be cleanly. The milker should milk with clean, dry hands. The cows' udders should also be clean; a perfect score is secured only by washing them thoroughly and then wiping dry. Wiping with a moist cloth is the next best thing, and wiping

with a clean, dry cloth or brush gives one point on the score, if done several minutes previous to milking, so that the dust can settle before the milking begins. If the milker, after sitting down to milk, gives the udder a rub with his hands or a dry cloth, he may stir up dust that will fall back into the milk pail. Such a method is generally worse than doing nothing and should have no credit.

It would be desirable to have all scoring done at milking time, but this is impracticable, as it would limit the work of the inspector to two or three dairies a day. Careful questioning by the inspector, with close examinations, will usually give him a fairly accurate idea of the method of milking. If, for instance, he is told that the udders are carefully washed daily, while inspection shows lumps of manure attached to the long hairs near the teats, only one inference is possible. Sediment in the milk or dirt on a strainer cloth tells the story of a dirty udder.

Handling Milk.—Milk, as soon as drawn, should be immediately removed from the stable so that it may absorb no odors or dust. If for convenience, several milkers fill one can in the stable, a perfect score could not be given even if the can is promptly taken to the milk room when full, for it is bad practice to pour milk in the stable, and at least half a point should be deducted for that. The score should, however, be higher when, as stated above, each can is removed to the milk house as soon as filled than if the milk remained in the barn till all the cans were filled. When two or more cows are milked to fill a pail, which is then taken to the milk house, the score would not be quite perfect, but would be better than where the milk is poured in stable air.

As soon as the milk reaches the milk room it should be cooled. This is best performed by running it in a thin sheet over a surface kept cool by ice water. Spring water of a temperature under 60° F. has much merit for cooling milk, though it is not as good as ice. Prompt and efficient cooling is desired, and the advantages of such cooling more than offset any possible injury from the extra exposure of the milk to the air. Where milk is sold by the can it is frequently cooled by setting the cans in tanks of water. This is better than no cooling, especially if ice water is used, and deserves some score for both promptness and efficiency; but it is not as satisfactory as running the milk over a cooler as soon as each cow is milked, which alone gets a perfect score. Sometimes the evening milk is properly cooled while the morning milk is delivered warm. This practice will give one-half the score for cooling, provided the two kinds of milk are not mixed, in which case the score would be zero.

The cleanliness of the persons who do the work in the milk house is allowed 2 points on the score card.

Storing.—This refers to conditions where the night's milk is held over for delivery in the morning. When the producer goes to the trouble and expense of two deliveries a day, as in some southern latitudes where ice is not plentiful, that extra delivery can offset the absence of storing facilities and give a perfect score on this item, though from the standpoint of economy ice is often less expensive than the second delivery.

Transportation.—Transportation is to be scored from the same viewpoint as stables, to wit, the adaptability of the method to the results desired when those results are needed. The word here means transportation as far as the producer is responsible—delivery to the railroad station, for instance. The transportation which is incident to distribution is not rated here.

TRANSPORTATION BETWEEN COUNTRY AND CITY

Inspectors should pay particular attention to the care milk receives after it leaves the farm and before it reaches the city. By carefully studying the conditions in his territory, the inspector may be of great service in improving them. Train schedules may sometimes be adjusted so that milk does not have to stand so long in the heat before shipment. Covered sheds or stands for the protection of milk awaiting shipment are extremely desirable. Proper provision for icing or otherwise refrigerating milk, especially on long hauls, should be provided. In mixed cars, crates of chickens, hides and other matter which might contaminate milk should be kept at a distance. Cans should be sealed, so that train employees cannot drink from the lids—a wasteful and insanitary practice.

At the city terminal, milk cars should be switched to the milk platform expeditiously, so that there is no unnecessary delay. Milk dealers must remove milk from railroad platforms within a short time and transport it quickly to the plant.

REFERENCES

(1) Inspection of Milk Supplies. Circ. 276, U. S. Dept. Agri.
(2) Ventilation of Farm Barns. Tech. Bul. 187, U. S. Dept. Agri.
(3) Farm Dairy Houses. Farmers' Bulletin 1214, U. S. Dept. Agri.
Health Officer Letters, Nos. 20 and 21, U. S. Dept. Agri.
Parker, H. N., City Milk Supply.
MacNutt, J. S., The Modern Milk Problem.
King, F. H., Ventilation for Dwellings, Rural Schools, and Stables.
King, F. H., A Textbook of the Physics of Agriculture.

CHAPTER IX

INSPECTION IN THE CITY

CITY MILK PLANTS

Middlemen, or city milk distributors, now occupy an important place in the market milk industry. They receive milk from the country, usually pasteurize and bottle it, and deliver it to the consumer.

The city milk plants must be inspected to see that equipment of a sanitary type is used and that sanitary methods are followed in the plant. It is necessary to see that all milk-handling apparatus is properly constructed. The arrangement and layout of the plant must be considered; the milk-handling rooms should be separate from those where cans and bottles are washed, and all rooms should have tight sound floors and tight smooth ceilings. There should be ample provision for drainage, ventilation and light in milk-handling rooms. The cleanliness of the rooms is important and much attention must be given to the methods used in cleaning the milk-handling apparatus and bottles. All such apparatus should be thoroughly steamed or otherwise treated after cleaning.

The inspector should always have an accurate thermometer, and note should be taken of the temperature of the milk as received, the temperature used in pasteurization, and the final temperature of the milk after it is put into the bottles. Much attention should be given to the pasteurizing process to see that the proper temperatures are used, and it is a good plan to make tests of the efficiency of the process from time to time. The cleanliness and health of all milk handlers is, of course, very important.

City milk plants have a wide range of capacity, equipment and methods. They vary from the huge city plants receiving milk by the trainload to the one-room building of the small milk-peddler.

SCORE CARD FOR CITY MILK PLANTS (1)

All of the varying styles of city milk plants need careful inspection, but the principles governing the business of the middlemen are the same as those governing the producer. Milk should be exposed to the air as little as possible, and the air should be pure; milk should not be han-

dled in unclean utensils, and it should always be kept cool. Consequently, in city plants as in dairy inspection, the same general principles must govern the inspector. A score card for city milk plants, based on these principles, has been devised by the Bureau of Dairy Industry, U. S. Department of Agriculture. It has been found in practice to be adapted to small and large plants. It is shown on pages 120 and 121.

The city milk score card, like that for dairy farms, is divided into two parts, one for equipment and one for methods. Here again, methods, being of greater importance, are given more credit.

Equipment.—*Building Location.*—The location of the building should be free from surroundings such as stables, dumps, etc., which might give off offensive odors and dust-borne infection.

Arrangement and Construction of Building.—There should be separate rooms for the various plant operations. It is particularly important that a separate room be provided for handling the milk. Such a room may more readily be kept free from flies, dust and odors.

All floors should be of non-absorbent material, so that milk will not soak into them, causing odors and sources of contamination. Concrete, glazed tile and certain composition floorings have proved satisfactory for milk-plant floors.

As far as possible, hospital construction should be used throughout the plant. Walls and ceilings should be kept smooth, tight and cleanable. Glazed white tile, or concrete or brick coated with a waterproof, white enamel paint, give an attractive finish and are easily cleaned.

Floors must be properly pitched so that there are no standing pools of water or waste. Sewage and waste should flow through trapped drains to a sewage disposal system or into a city sewage system.

There should be at least 1 square foot of window glass for each 10 square feet of floor space. This is especially important in the receiving and handling rooms, and severe cuts are warranted for deficiencies in those places. Light should be evenly distributed so that all parts of the room receive its beneficial effect.

In small plants, air may be admitted through windows; but in the large plants a forced-air system of ventilation is desirable. Perfect credit should be allowed only when there is some means of changing the air without causing direct draft on the milk-handlers, or on milk machinery.

Outlet flues are essential to carry off impure air, steam, vapors and odors.

Screens should be provided for all windows and doors, especially those of the receiving and milk-handling rooms. Deduct for torn or poorly fitting screens and lack of self-closing springs on screen doors.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF DAIRY INDUSTRY

SANITARY INSPECTION OF CITY MILK PLANTS

SCORE CARD

Owner or manager..

Street and No...

City.................................... State.............................

Trade name...

Number of wagons........... Gallons sold daily { Milk......................... / Cream.........................

Permit or License No...............

Date of inspection.............................., 192

Remarks:...

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...................................*Inspector.*

Equipment.	Score. Perfect.	Allowed.
Building:		
Location: Free from contaminating surroundings	2	
Arrangement	7	
Separate receiving room	1	
Separate handling room	2	
Separate wash room	1	
Separate salesroom	1	
Separate boiler room	1	
Separate refrigerator room	1	
Construction	12	
Floors tight, sound, cleanable	2	
Walls tight, smooth, cleanable	1	
Ceilings smooth, tight, cleanable	1	
Drainage	2	
Floors	1	
Sewer or septic tank	1	
Provision for light (10 per cent of floor space)	2	
Provision for pure air	2	
Screens	1	
Minimum of shafting, pulleys, hangers, exposed pipes, etc	1	
Apparatus	15	
Boiler (Water heater, 1)	2	
Appliances for cleansing utensils and bottles	2	
Sterilizers for bottles, etc	2	
Bottling machine	1	
Capping machine	1	
Washbowl, soap, and towel in handling room	1	
Condition	6	
Milk-handling machinery	3	
Pipes, couplings, and pumps	2	
Cans	1	
Laboratory and Equipment	2	
Water supply	2	
Clean and fresh	1	
Convenient and abundant	1	
Total	40	

Methods.	Score. Perfect.	Allowed.
Building	14	
Cleanliness:		
Floors	3	
Walls	2	
Ceilings	2	
Doors and windows	1	
Shafting, pulleys, pipes, etc	1	
Freedom from odors	2	
Freedom from flies	3	
Apparatus	7	
Cleanliness:		
Thoroughly washed and rinsed	3	
Milk-handling mach	2	
Pipes, cans, etc	1	
Sterilized with live steam	3	
Milk-handling mach	2	
Pipes, cans, etc	1	
Protected from contamination	1	
Bottles	7	
Thoroughly washed and rinsed	3	
Sterilized with steam 15 min.	3	
Inverted in clean place	1	
Handling milk	22	
Received below 50° F (50° to 55°, 2) (55° to 60°, 1)	3	
Rapidity of handling	2	
Freedom from undue exposure to air	2	
Cooling	5	
Promptness	2	
Below 45° F (45° to 50°, 1)	3	
Capping bottles by machine	2	
Bottle top protected by cover	1	
Storage; below 45° F (45° to 50°, 3; 50° to 55°, 1)	4	
Protection during delivery (Iced in summer)	2	
Bottle caps sterilized	1	
Inspection	6	
Bacteriological work	3	
Inspection of dairies supplying milk (2 times a year, 2; once a year, 1)	3	
Miscellaneous	4	
Cleanliness of attendants (Personal cleanliness, 1; clean, washable clothing, 1)	2	
Cleanliness of delivery outfit	2	
Total	60	

Score for equipment.....plus score for methods.....equals Total Score.....

Note.—If the conditions in any particular are so exceptionally bad as to be inadequately expressed by a score of "0" the inspector can make a deduction from the total score.

Apparatus.—A boiler is essential, so that plenty of steam will be available for treating utensils and heating wash water. Bottle and can-washing facilities are necessary, and cuts should be made wherever these are inadequate.

It is desirable that the milk be touched by clean machinery rather than subjected to a chance of manual contamination; therefore, allowances are made for bottling and capping machines.

Credit is given for adequate means for the washing of operators' hands in the milk-handling room. Hands often become soiled by handling cases, adjusting machinery, etc.; and it is desirable to have a nearby place where they may be readily cleaned.

The condition of the milk-handling equipment, pipes, pumps, cans, etc., should receive careful inspection. Cuts should be made for badly battered surfaces which are hard to clean. Piping through which milk flows should be of sanitary type, and should have frequent hand couplings so that it may be taken down for cleaning.

Laboratory.—Two points credit are given for laboratory and equipment. Perfect scores should be given only where there are facilities for both chemical and bacteriological tests.

Water Supply.—Credits are given for the cleanliness, freshness, convenience and abundance of the water supply. Cuts should be made if there is any question of the purity of the water supply. Further deductions are made if the volume of water is not abundant for all needs, and if faucets or supply lines are at considerable distance from where water is needed, especially for washing apparatus.

Methods.—*Building.*—Careful examination should be made of walls, floors, ceilings, doors and windows. If dust and dirt are found, deductions should be made depending upon the amount of dirt, and the likelihood of its falling or being blown into milk or upon apparatus.

The air in the plant should be free from disagreeable odors, in order to obtain a perfect score. Special attention should be paid to the milk-handling room.

It is extremely difficult to keep flies out of all parts of a milk plant. They swarm in when doors are opened, and enter on dirty bottles, cans, etc., which are brought in. In scoring, keep this fact in mind and base scores on practical conditions under careful management. The receiving room and milk-handling room should be kept entirely free from flies.

Apparatus.—All apparatus coming in contact with milk should be closely scrutinized. Pay particular attention to valves on bottling machines, coils in pasteurizing vats, coolers, piping, and capping machinery. Deposits of milk solids and other evidences of imperfect cleaning deserve deductions.

Observations should be made as to the quantity of steam or hot water used, the length of treatment, and the probability that all parts of the apparatus receive sufficient heat. All apparatus should be subjected to a temperature of at least 205° F. for at least five minutes. Chemical solutions should be regularly tested.

Milk cans should receive special attention. Dirty cans may be the source of great contamination. Examination of milk cans in seventeen city milk plants showed that 59 per cent of the cans would have given a contamination of over 1000 bacteria per cubic centimeter to milk placed therein. Inspectors should take frequent samples from empty cans. For this purpose each can is rinsed with 500 c.c. of sterile water, a portion of which is then plated for bacterial count. The contamination per cubic centimeter of milk is then computed by the following formula.

$$\frac{\text{Bacteria per c.c. of rinse water} \times \text{c.c. of water}}{\text{c.c. in container}} = \text{Contamination per c.c. of milk.}$$

A 10-gallon can holds 37,854 c.c.

Bottles.—In small plants bottles are usually washed by hand or on revolving brushes, while in the large plants, special machines are used. Whatever method is followed, bottles should be perfectly clean. Examine especially the rim or " cap seat," and the bottoms. Perfect treatment may be obtained in a steam oven where the bottles may be subjected to steam for fifteen minutes. Satisfactory results are obtained when the bottles are treated with sprays of boiling water, jets of steam, or chemical solutions. After treatment, bottles should be inverted so that there is no chance for contamination from dust or drip from other cases.

Examine bottle-washing machinery for defects in operation. Spray holes for water or steam should not be clogged. Pumps should be in proper working order. Machines depending upon jets of hot water should be tested with a thermometer to make sure that the water is at or near the boiling point. Bacteriological tests on bottles should be made in a similar manner to those for cans.

Handling Milk.—Thermometers should be used to determine the actual temperatures at which milk is received at the city plant; and credits should be given as indicated on the score card. Milk should be handled rapidly and without undue exposure to the air. Deductions should be made for the following faults: cans of milk allowed to stand outside of refrigerator; uncooled milk remaining in vats for long periods of time; vats, cans, coolers, bottles, etc., uncovered so that they or the milk they contain may be contaminated.

Cooling should be prompt and efficient. Raw milk entering the plant must be either pasteurized or cooled at once, and pasteurized milk should be quickly chilled after pasteurization. Thermometers should again be used to take the temperature of milk as it comes from the cooler. The temperature of storage rooms or vats should be recorded.

Credit is given if the bottles are capped by machines, thus doing away with the danger of contamination by human hands. If the bottle mouth is protected by an outside covering, an additional credit of 1 point is given.

Bottled milk should be well iced on the delivery wagon, in warm weather. The cases of milk should be protected from street dust and flies by a clean blanket or tarpaulin.

Bottle caps should be purchased in tubes. Such caps are usually sterile or nearly so. Deductions should be made where caps are in open containers, subject to contamination and handling.

Inspection.—Credit is given when city plants carry on their own bacteriological work and farm inspection. No credit is given if they depend upon health officials for this work. Each distributor himself, or through his agents, should be in intimate contact with his producers. He is responsible for their milk when it comes into his possession; and he should be sure that it is of the desired quality.

Miscellaneous.—Deduct for attendants with dirty hands or clothing, and also for the use of tobacco in the milk-handling rooms. Extra credit is allowed for clean suits worn by milk-handlers.

Inspect the delivery outfit, and score it, especially for freedom from dirt, old milk, etc. Compartments where milk is kept should be closely observed.

CONTROL OF PASTEURIZATION

Milk inspectors should keep in very close touch with pasteurizing plants, both in the country and in the city. The mere presence of proper equipment does not insure safety; frequent bacteriological tests on pasteurizing efficiency and on subsequent recontamination should be made. Recording thermometers should be installed on every pasteurizer, and should be frequently tested for accuracy, against a standard thermometer. The record charts should be closely examined to make sure that the milk has all been heated to at least 142° F. for at least thirty minutes.

In bacteriological tests, the average count of the raw milk can be used as a basis for determining bacterial reductions due to pasteurization. Suppose the raw milk contains 2,000,000 bacteria per cubic centimeter,

and the milk at the end of the holding period contains 20,000 bacteria per cubic centimeter. The reduction is then 1,980,000 per cubic centimeter, or 99 per cent of the original 2,000,000. In this case, the pasteurizing efficiency was 99 per cent, a very good record. If the same milk has a count of 35,000 bacteria per cubic centimeter after having been cooled and bottled, there is a recontamination of 15,000, or a 75 per cent increase over the count from the holder. The finished product, then, has 1,965,000 bacteria per cubic centimeter less than the original raw milk; therefore the efficiency of the entire process is only 98.25 per cent. By taking samples at different intervals during pasteurization, faulty processes can be discovered and rectified.

The following series of samples should be taken and examinations made as indicated:

1. Raw milk at entrance to heater, for bacteria and temperature.
2. Heated milk after holding, for bacteria, temperature and holding time.
3. Milk as it comes from the cooler, for bacteria and temperature.
4. Milk in bottles and cans for bacteria and temperature.
5. Milk in bottles and cans after storage, for bacteria and temperature.
6. Empty bottles and cans for efficiency of treatment.

CONTROL OF COMMUNICABLE DISEASES IN MILK PLANTS

Pasteurization, properly performed, will kill all disease-producing organisms. Great care should be exercised against recontamination in the plant with such bacteria. All employees who come in contact with milk or milk machinery and containers should undergo careful medical inspection. There should be no carriers of typhoid, tuberculosis, diphtheria, septic sore throat or other infectious diseases. The danger of such carriers has already been stressed.

Milk plants should be extremely careful about the delivery of milk to quarantined houses. Milk may be poured into the consumer's receptacle at the door. Pasteboard or fiber containers which can be burned by the consumer, may be used. If glass bottles are delivered, they should be removed only after complete sterilization under the supervision of the health department.

INSPECTION OF STORES SELLING MILK

Three factors should be considered in the inspection of retail stores:

1. Whether or not the same quality of milk is being delivered to stores as is being retailed by distributors to consumers direct.
2. Facilities for keeping milk at the stores.
3. Whether or not the milk is being held from one day to the next.

Careful study should be made of the grade of milk sold at the stores. Samples should be taken and compared with samples obtained from the same distributor or producer as delivered on the retail routes. In no instance should dairies be allowed to deliver milk of undesirable quality to stores.

There should always be adequate facilities present at the store for the proper storage and handling of milk. Without such facilities, no permit should be issued to the store. A refrigerator or ice-box is necessary. The storage of fish, meats, vegetables, etc., in the same compartment with the milk should be discouraged. When the milk is delivered at the store before anyone is present to receive it, provision should be made to place the milk in a place protected from sunlight, cats, dogs and other animals. The milk should always be placed in the refrigerator as soon as possible. Often the storekeepers are remiss in this respect, and leave the crated milk behind or on the counter to have it handy. Such a practice is extremely undesirable. The same temperature requirements as are prescribed for the retail delivery of milk should hold for the handling of milk at the stores. All milk should be kept at or below 50° F. The sale of " dipped milk," if allowed, should be strictly regulated to avoid danger of milk-borne epidemics.

Milk, as sold by stores, should be fresh. Milk delivered one day at the store should not be sold the following day. Measures should be inaugurated which will result in the collection of all milk left over at the end of the day. Dealers should use such milk for manufacturing purposes. It should not be allowed to remain in the store over twenty-four hours.

Stores may serve as very useful mediums for milk distribution if properly controlled. From them, consumers should be able to secure, at any time of the day, clean, cold milk at reasonable prices.

Stores in some cities still sell " bulk " milk, milk dipped or drawn from a can or other receptacle. (2) If properly controlled, such a system may somewhat reduce the price of milk to the consumer. It has, however, certain disadvantages which are apparent to the sanitarian. The consumer's receptacle may not be clean; or the milk served may be contaminated or improperly refrigerated in the store.

TAKING SAMPLES IN THE CITY

Frequent sampling of milk in the city is necessary, in order that the laboratory can determine whether or not chemical and bacterial standards are being complied with. The best method is to take samples in the original package, such as a pint or quart bottle. In this way there is no chance for contamination.

Sampling Device.—Samples taken from cans, vats, dippers, etc., present a more intricate problem. The inspector must be careful not to insert any sampling device into the milk which might contaminate either the sample or the rest of the milk. This is especially important in taking samples for bacteriological examination. Many sampling devices are in use; but that used by the Health Department of Baltimore, Md., is probably best adapted to the purpose of taking samples for bacterial count. A sketch of the device is shown in Fig. 31. It consists of a 2- to 4-ounce (the size may be varied) tincture mouth square glass bottle with a ground-glass stopper. A thin copper wire, 24 to 30 inches long, is attached by one end to the stopper, the other end being secured around the neck of the bottle. The wire is then coiled loosely around the bottle, the whole being covered with a good grade of paper and sterilized in hot air, in accordance with laboratory practice for bacteriological equipment. Two pieces of paper are used, one placed around the bottom of the bottle, the other overlapping and covering the stopper and sides. Before a sample is taken, the contents of the can must be thoroughly stirred, paddles about $1\frac{1}{2}$ inches wide being used for this purpose. These paddles, which should be made of metal, are wrapped in paper and also sterilized.

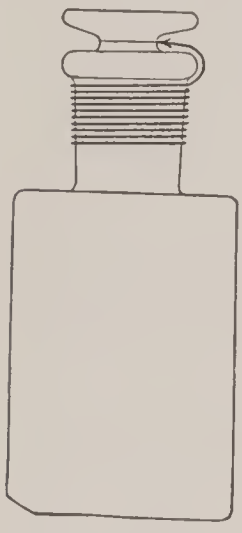


FIG. 31.—Sample bottle used in the collection of bulk milk for bacteriological examination.

Sampling.—A stirring paddle is withdrawn from its sheath of paper, care being taken not to touch that part which enters the milk. The milk is then thoroughly stirred. After this, the lower paper is removed from the sample bottle, the operator holding the stopper inside its paper cover. The weight of the bottle causes it to sink into the milk, uncoiling the wire. When the bottle is withdrawn it is held in one hand, while the stopper is replaced with the other. The wire is looped or coiled on the outside. A bottle or paddle should never be used without being washed and sterilized.

Samples should be taken at many different points, not only to

determine the condition of the milk, but to find the cause and responsible agency for undesirable conditions. Opportunities for sampling exist at railroad stations, milk plants, stores and lunch rooms, and on delivery wagons. As soon as samples are taken, they should be thoroughly iced and delivered to the laboratory within a short time. A complete record should be kept of the owners' names and addresses, time and place where samples were collected, time delivered to the laboratory, and any other general information of historical interest.

DENATURING MILK

It is the custom of officials in many cities to condemn milk because of the failure of the milk dealers to comply with certain temperature standards. Usually, this milk is disposed of by emptying it into the gutter, though some attempts have been made to denature the milk by adding certain substances which would render it unfit for use in its fluid state. It is unfortunate that this milk, which is valuable for feeding farm animals, should be needlessly wasted. This loss can be prevented if the milk is returned to farms where it can be utilized for feeding live stock. Condemned milk should also be used in the city for making casein and for other purposes.

The Bureau of Dairy Industry, United States Department of Agriculture, conducted some experiments in order to devise some practical method of denaturing milk, so as to prevent its sale as market milk and yet leave it in a condition suitable for feeding farm animals. The work proved that the use of a rennet solution is effective for this purpose at the usual temperature at which milk is condemned.

In these experiments, a 3 per cent water solution, made from powdered rennet of a strength of 1 to 30,000, was used; and 40 c.c. of this solution were added to 5-gallon cans of milk at different temperatures. The tests were made in a room where the temperature was 80° F., as that is about the temperature of the air in summer when most of the milk is condemned. In one test the rennet solution was added to a 5-gallon can of milk at a temperature of 50° F. In one hour and fifteen minutes, the milk was slightly thickened, its temperature then being 57°. Thirty minutes later, the temperature had reached 59° and a soft curd formed. An equal amount of milk at an initial temperature of 65° was treated at the same time. In one hour and ten minutes, the milk in this can was firmly coagulated, and it is probable that the rennet had produced the desired effect in much less time. At the end of this period, the temperature had been raised only 1.2°, or to 66.2° F.

In the light of these experiments, it is believed that if a rennet solution of this strength is added to condemned market milk, satisfactory results can be secured under ordinary conditions without the disadvantages of the other methods which have been tried.

If a 3 per cent solution is made from rennet, strength of 1 to 30,000 about $2\frac{1}{2}$ ounces (80 c.c.) of this solution will be required for 10-gallon can of milk at a temperature of 53° or higher.

VARIOUS TESTS MADE OF MILK

It is beyond the province of this book to describe in detail the tests made for determining the desirability of milk. Such tests are taught in other courses and are fully described in other textbooks. The student of market milk should have in mind the usual tests; and for this purpose brief descriptions will be given.

Bacteria.—Chapter V refers to bacterial tests commonly used. For total counts of living organisms, the plate method is used. In this method a nutrient medium is inoculated with known quantities of milk, and poured into sterile glass dishes, which are allowed to incubate for a certain length of time. The resulting " colonies " are counted, and the number of bacteria per cubic centimeter of milk estimated. Details of the plate method are given in " Standard Methods for the Bacteriological Examination of Milk," which may be purchased from the American Public Health Association, 370 Seventh Avenue, New York.

Direct Microscopic Examination.—In this method, a small known quantity of milk is distributed evenly on a glass slide. (3) The area of the microscopic field having been measured, the slide is stained and examined under the microscope. A number of fields are counted, and from these data estimates are made of the number of bacteria in the total amount of milk used.

The test has the advantage of being quick and cheap. Furthermore, it is applicable on field surveys where the plate method is impossible. The error in estimate is probably quite large, and the method does not give a clear differentiation between living and dead organisms. For this reason it is practically useless in dealing with pasteurized milk, except in comparison with the plate count, for estimating the quality of the milk before pasteurization.

Considerable experience, especially in staining, is necessary in order to secure good results. The test is considered to be particularly applicable to raw milk having relatively large numbers of bacteria. It should be used for general groupings, rather than for estimates of actual counts.

Fat.—The Babcock test is usually run to determine fat, (4) and has

held in court cases. Sometimes the more complicated chemical tests for fat are used; but for all practical purposes the Babcock test is sufficient.

Solids.—Total solids or solids-not-fat may be estimated from the percentage of fat and the specific gravity. (See Appendix for tables.) For more accurate work, a weighed sample of milk is evaporated to dryness and re-weighed.

Specific Gravity.—The specific gravity of milk is usually determined by the use of a lactometer. This is a cylindrical instrument (Fig. 32) which is so weighted that it floats upright in milk. A graduated scale gives a reading on the Quevenne lactometer which may be easily read directly as specific gravity. For more delicate work, a Westphal balance is used.

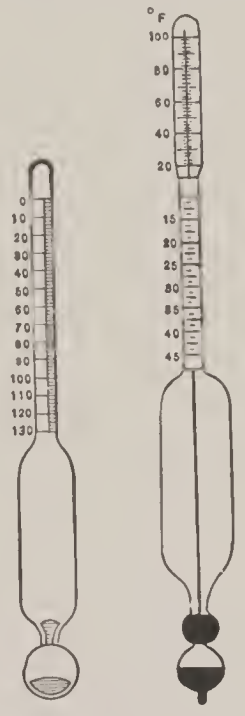


FIG. 32.—Board of Health and Quevenne lactometers.

Tests for Skimming and Watering.—Laws governing the chemical composition of milk usually specify two things: first, milk must contain a certain definite percentage of fat, solids-not-fat and total solids; and second, milk must have nothing added to or subtracted from it. The first specifications can easily be determined by direct tests for fat and solids. The second specifications are more difficult to determine. They relate specifically to milk which has been adulterated by skimming or watering, or both. Milk may be adulterated and still be above the legal standard for fat and solids. For instance, if the legal standard is 3.5 per cent fat, a 4 per cent milk can be partially skimmed so that it contains just the legal requirements. Such a milk would be legally above standard, but it would be classed as adulterated.

It has been shown in the chapter on the chemistry of milk that quite a definite relation exists between the percentage of fat and other solids. Individual samples may vary from the relation shown in Table 9; but whenever the variation is considerable the samples may be looked upon as suspicious. Fat with comparatively high solids-not-fat indicates skimming; while fat with comparatively low solids-not-fat indicates watering.

In all cases of farm milk where suspicious samples are found, it is well to go to the dairy and secure a mixed sample of herd milk of known purity.

For the detection of added water, several methods are available. The refractometer and the cryoscope are the instruments most frequently used.

Refractometer.—The refractometer is used to read the refractive index of milk serum. The instrument in common use is the "Zeiss immersion refractometer," and several varieties of serum, such as the "acetic," "sour," and "copper" serum, may be used.

Ackerman states that the refractometer reading in normal milk is from 38.5 to 40.5, with an average of 39.0. He gives the following table showing the relation between added water and the refractometer reading:

TABLE 23

Relation of Refractometer Reading to Added Water

Per Cent Added Water.	Refractometer Reading.
5	37.7
10	36.7
15	35.7
20	34.8
25	34.0
30	33.3
35	32.6
40	32.0
45	31.4
50	30.9

Added water is indicated, with the "acetic serum," by refractometer readings below 39; with the "sour serum," by readings below 38.3; and with the "copper serum," by readings below 36.

For a description of refractive index, see the Chapter on Chemistry as Applied to Market Milk.

Cryoscope.—For a number of years, investigators have pointed out that the freezing point of milk is practically constant at −0.55° C. Numerous instruments have been made to determine the freezing point of milk, and thus estimate the amount of added water.

The most recent and best known is the "Hortvet Cryoscope," invented by Julius Hortvet, of Minnesota. (5) With this apparatus, the freezing point of milk is quickly and accurately determined, and the percentage of added water calculated. Mr. Hortvet states that " . . . when the freezing point of the original milk (e.g., a herd milk) is unknown, the addition of water may safely be reported in an amount as low as 3 per cent." The nearer the freezing point of milk approaches the freezing point of water (0° C.), the greater the amount of

added water. For instance, a freezing point of −0.459° C., in milk, indicates approximately 16.5 per cent of added water.

Nitrate Test.—A number of chemical tests for the detection of nitrates in milk have been devised. These tests are based on the assumption that water supplies contain small quantities of nitrates, and that the presence of nitrates in milk proves that water has been added. Barthel shows (6) that such assumptions are not fully warranted, for two reasons: first, many water supplies contain no nitrates; and second, the washing of milk utensils in water containing a large percentage of nitrates would cause the milk to react to the test. He adds the caution that the nitrate test should be used only as an indication and not as positive proof.

Temperature.—When samples are collected, temperatures should be taken to see how the milk is being refrigerated. A standard thermometer should be used. It should be carefully cleaned before it is inserted in milk and should not be used in samples intended for bacteriological examination.

Acidity.—High acidity in market milk is undesirable. It indicates that the milk is being soured by the action of the lactic acid bacteria on milk sugar. Milk usually tastes sour when about .3 per cent of acid is formed. When the acidity exceeds .2 per cent, the milk is usually unfit for pasteurization or commercial use, because it will rapidly sour and disintegrate.

Shaw states that: (4)

"Acidity in milk is attributable to two causes, 1, the presence in milk of acid phosphates and perhaps of carbon dioxide, and 2, lactic and other acids produced by the decomposition of the milk sugar by bacterial action. When freshly drawn milk is acid to phenolphthalein, this acidity is from 0.07 per cent to 0.08 per cent and is owing to causes given under 1. Lactic acid is not present in freshly drawn milk; it develops only on standing. Milk is not sour to the taste until it has a total acidity of at least 0.3 per cent.

"For convenience, the total acidity of milk is usually calculated as lactic acid. The principle upon which the determination of acidity is based is the well-known chemical action of acids upon alkalies. To illustrate, the action of hydrochloric (sometimes called muriatic) acid on a solution of caustic soda may be taken. This acid has a sharp and very sour taste, while caustic-soda solutions have a soapy feel and a peculiar odor, and if sufficiently strong will attack the skin. If the solution of caustic soda is slowly added to the hydrochloric acid, the sour taste will gradually disappear until the exact point of neutrality is reached, when a new substance is produced—sodium chloride, or common salt, which has neither the acid properties of the one nor the alkaline properties of the other. The sense of taste, however, is not sufficiently sensitive to determine when the exact point of neutrality has been reached.

Phenolphthalein is an organic compound, having the property, when in solution, of turning pink with alkalies and remaining colorless with acids. Such a substance is called an indicator because it indicates by a color change when a certain chemical reaction has taken place."

Preservatives.—Tests are usually run on suspected samples for formaldehyde, borax, boracic acid and hydrogen peroxide.

Coloring Matter.—Milk dealers have been known to increase the color of milk by adding yellow coloring matter. When such practices are suspected, tests should be made for annatto and coal-tar colors.

Sediment.—Because the amount of visible dirt or sediment, as shown by the sediment test, is no criterion of the bacterial count of milk, it should not be assumed that such test should be neglected or its use curtailed. The sediment test is an important one and should be carried out by all health officials.

FIG. 33.—Two types of sediment testers.

The presence of sediment in milk is evidence that such milk has not been handled properly. It shows that at some point in its production someone has neglected, or carelessly carried out, some important step which is essential for the production of clean and safe milk. The sediment in itself may not be dangerous; but, on the other hand, it may be a real source of infection; and it is a warning to all health officials that this particular supply must be carefully investigated. It has been shown that tubercle bacilli may be present in the manure from tubercular cattle, and as such material often constitutes the sediment to a large extent, milk containing this sediment may be dangerous.

The proper use of the sediment test may be of great assistance in improving the milk supply. This is one test which brings before the producer, in a concrete and convincing manner, the cleanliness of his product. It is a test which may be made to demonstrate the carelessness of methods used. By being shown the actual dirt present, the dealer is more easily convinced that his methods are at fault.

The sediment tester is very simple in construction and operation. Various makes are on the market; some are made for laboratory use

only, and by their use a large number of samples may be tested in a short period of time; others are made for field use, and can be best used at receiving platforms and on the farms. The disks should be given a rating and records kept. The rating is arrived at by comparing the disk with a standard series of prepared disks which have been given numerical values.

Fermentation.—The fermentation test is sometimes used to roughly determine the character of bacteria in milk. It is more often used in milk for cheese-making than for market milk. The test consists in pouring 40 c.c. of milk (Jensen) (7) into strong test-tubes having a uniform diameter of 2 centimeters. The tubes are then covered with a cap of zinc or aluminum, and placed in a water bath which is maintained at 38° C. (about 100° F.). Good, fresh milk is supposed to remain liquid for twelve hours, while inferior milk curdles. The curd varies in appearance in accordance with the predominant types of bacteria. Examination of the tubes is made at the end of twelve hours, and again at twenty to twenty-four hours:

The following classifications are made: (7)

State.	Appearance.	Type of Bacteria.
Fluid	Normal	Few of any.
Gelatinous curd	Even curdling. Few bubbles	Lactic acid.
Blown curd	Gassy. Casein driven to surface.	Lactic and gas producers.
Spongy curd	Gassy. Finer texture than above.	Gas producers. Few lactic.
Cheesy curd	Clear separation of whey	Peptonizers.

Alcohol Test.—This test usually consists of mixing equal volumes of 68 per cent alcohol and milk. If a coagulum is produced in market milk, it is considered to have undergone changes due to bacterial action. Positive tests in the milk from a single cow or small herd are believed to indicate abnormalities in the physical condition of the cow. Ayers and Johnson (5) report that positive tests obtained with milk from one cow or a small herd warrant a careful physical examination of the cows. They did not find, however, that there was a constant correlation between the alcohol test and the number of bacteria in mixed market milk.

Methylene-Blue Reduction Test (9).—The methylene-blue reduction, or reductase, test is not a new one. For many years much investigational work has been done in an effort to correlate reduction time with the number of bacteria in milk, but results have been somewhat widely divergent, on account of a number of factors, such as types of

bacteria in the milk. At present, most laboratory workers are averse to any attempts to use the methylene-blue reduction time for closely approximating the actual number of bacteria in milk.. Nevertheless, it has been generally accepted that milk may be roughly graded according to reduction time. Judged by this criterion, individual samples or groups of samples may at times give a misleading picture of the bacteriological condition of the milk. But the test is useful under certain conditions, and field man and dairy inspector would do well to consider the advisability of using it more freely. The chief uses of the reductase test are as follows:

1. To make a rough grouping of milk samples, to be followed by bacteriological examinations and farm inspection when the reductase test indicates that the milk is of poor quality.
2. In remote places where laboratory facilities are not available or it is impracticable to transport samples satisfactorily to the laboratory.
3. For educational work among dairy farmers and their families, to demonstrate quickly and strikingly the differences in milk quality and the effect of certain methods of production.
4. As a possible indication of mammitis or other udder derangements when freshly drawn samples " reduce," or lose their blue color, in abnormally short times. This may be an indication of streptococci or a high leucocyte count and calls for close physical examination of the udder and bacteriological examination of the milk.

The methylene-blue reduction test is fully described in the " Standard Methods for the Bacteriological and Chemical Examination of Milk," published by The American Public Health Association, 370 Seventh Avenue, New York, N. Y. It consists of adding a blue dye to a measured quantity of milk and incubating at about body heat, usually in a water bath. Milk containing large numbers of bacteria usually " reduces " in a short time (anywhere from a few minutes to $\frac{1}{2}$ hour), while milks of better quality remain blue for longer periods of time.

The American Public Health Association has tentatively graded milk according to its reduction time into the following groups:

Class 1. Good milk, not decolorized in $5\frac{1}{2}$ hours.
Class 2. Fair average-quality milk, reduction time 2 to $5\frac{1}{2}$ hours.
Class 3. Bad milk, reduction time 20 minutes to 2 hours.
Class 4. Very bad milk, reduces in 20 minutes or less.

Various bacterial count approximations have been assigned to these four classes, but most investigators prefer to think of reduction time as separate from any specific bacteriological correlation.

The equipment used for this test is inexpensive and easily carried around. Outfits adapted to field work, including water bath for incubating, test-tubes, pipettes, and tablets from which the methylene-blue test solution can be readily made, may be purchased for about $15.

Let us again point out that the methylene-blue reduction test is an indicator only and not always a reliable yardstick to measure the number or kinds of bacteria present in milk. Its results to be scientifically accurate, must be further checked and interpreted by additional research. But it has a usefulness not yet fully developed in educational work and for field work where a quick and rather rough method is needed for dividing milk samples into general groupings.

Other Tests.—Other reagents have been tried with special reference to changes in the hydrogen-ion concentration. Bromthymol blue and bromcresol purple (10) have been used. Results so far are inconclusive as regards the estimation of total bacterial counts; although some correlation was found with the number and growth of lactic organisms. Since these tests measure only acidity, they are not so useful as the methylene-blue test for determining total counts.

Flavor and Odor.—Milk should be free from undesirable flavors and odors. Evidences of putrefaction and souring are especially objectionable. Feed flavors and odors, such as those of garlic and silage, are not evidences of danger to health, but they are a distinct disadvantage from a commercial standpoint. There are no tests for flavors and odors except those "organolyptic" ones of taste and smell. If the milk is warmed, flavors and odors can be more readily detected. A complete discussion of judging milk for flavor and odor will be found in Chapter X.

GRADING MILK

Several cities have adopted the plan of grading market milk into several classes according to quality.

Milk grading, properly conducted, is a step in advance in dairy sanitation. Where an efficient grading system is in operation, consumers may select the class of milk which they desire and for which they are willing to pay. The health department is also aided in its efforts to inform consumers where milk of the highest quality may be secured. In addition, those dairymen who, by additional care and expense, produce a high-grade product are rewarded by greater financial returns.

Along with its advantages, milk grading puts great responsibility on the health department. For this reason, the matter should be carefully studied by administrative officials before such a system is adopted. No grading system should be considered which includes any milk not

perfectly safe for human consumption; the lowest grade should be safe milk.

In planning a grading system, it is desirable to have only a very few, clearly defined grades. A multiplicity of grades increases the work of administrative officials and causes confusion in the minds of consumers. Ordinarily three grades will suffice—Grade A Raw, Grade A Pasteurized, and Grade B Pasteurized. Certified milk may be included in Grade A Raw, or it may be sold under its own title. The distinction should be so clearly made that there will be no doubt that Grade A milk is better than Grade B milk.

Unfortunately, some cities have passed grading ordinances without having sufficient funds or personnel for proper enforcement. This has resulted in confusion. So-called Grade A milk has been sampled and found to be of lower quality than Grade B milk. Where such a condition prevails, it would probably be better to have no grading system at all. Especial care must be taken where a milk plant handles two different grades of milk. Strict precautions must be observed to make sure that the two grades do not become mixed or that one grade is not substituted for a higher grade. In such plants it is better to require that the highest grade be handled first in order that it may pass through the equipment before the lower grade.

In spite of the difficulties attending the operation of milk grading, such a system is desirable; but the system must be workable and capably enforced. If poor milk is allowed to masquerade under the title of Grade A, the public will be imposed upon, and its confidence in the system shaken. The milk producer, dealer and consumer will suffer, and the reputation of the health department will not be enviable.

There is a great variation in the requirements for different grades, as well as in the number of grades allowed.

Usually the higher grades include relatively small amounts of milk.

REFERENCES

(1) Kelly and Leete, Inspection of Milk Supplies. Circ. 276, U. S. Dept. Agri.
(2) Kelly, The Control of Bulk Milk in Stores. B. A. I. Circ. 217, U. S. Dept. Agri.
(3) Breed and Brew, Counting Bacteria by Means of the Microscope. N. Y. (Geneva) Sta. Tech. Bul. 49.
(4) Shaw, Chemical Testing of Milk and Cream, A 12, U. S. Dept. Agri.
(5) Hortvet, The Cryoscopy of Milk. Jour. Ind. Eng. Chem., Vol. 13, No. 3, p. 198.
(6) Barthel, Methods Used in the Examination of Milk and Dairy Products. Translation by Goodwin.
(7) Orla-Jensen, Dairy Bacteriology. J. & A. Churchill, London, Eng.
(8) Ayers and Johnson, The Alcohol Test in Relation to Milk. Bul. 202, U. S. Dept. Agri.

(9) Hastings, Comparative Value of Quantitative and Qualitative Bacteriological Methods as Applied to Milk, with Special Consideration of the Methylene Blue Reduction Test. Jour. Dairy Science, Vol. 2, No. 4.

(10) Hastings and Davenport, The Relative Value of the Methylene Blue Reduction Test, the Bromthymol Blue Test, and the Bromcresol Purple Test in Determining the Keeping Quality of Milk. Jour. Dairy Science, Vol. 3, No. 5.

U. S. Dept. Agri. Health Officer Letters Nos. 34, 45, 48, 47, 52, 55, 56, 42.

Wing, Milk and Its Products.

Stocking, Manual of Milk Products.

Dahlberg and Garner, The Alcohol Test as a Means of Determining Quality of Milk for Condenseries. Bul. 944, U. S. Dept. Agri.

Harding and Prucha, Germ Content of Milk as Influenced by Visible Dirt. Ill. Sta. Bul. 236.

Ross, Laboratory Guide in Market Milk.

Farrington and Woll, Testing Milk and Its Products.

Van Slyke, Modern Methods of Testing Milk and Milk Products.

Standards for the Bacteriological Examination of Milk, American Public Health Association.

Frost, A Rapid Method of Counting Living Bacteria in Milk and Other Richly Seeded Materials. Jour. Am. Med. Assn. (66), p. 889.

Cooledge and Wyant, The Keeping Quality of Milk as Judged by the Colorimetric Hydrogen Ion Determination. Jour. Dairy Science, Vol. 3, No. 2.

Winter and Parmentier, La Cryoscopie du Lait. Revue Gén. du Lait, Vol. 3, p. 193.

CHAPTER X

SCORING OF MILK AND CREAM

In the chapter on inspection in the city, reference was made to the use of milk and cream contests, to improve cities' milk supplies. In addition, there are state-wide and even national contests to educate dairymen to produce milk of a higher grade.

Student teams from agricultural colleges and schools compete against each other in scoring milk and cream. The training received in this way and in class work is of great value to the student, teaching him to recognize and measure desirable and undesirable qualities in market milk. Such a knowledge is valuable whether he is to become a milk producer, a dealer or an inspector.

SCORE CARDS

Score cards for milk and cream have been devised. These cards assume certain mathematical ratings for standards of quality. On pages 140 and 141 will be found facsimiles of the milk and cream card.

The card shown is the one in use by many of the agricultural colleges and is the type used in "Students' Judging Contests for Dairy Products."

HANDLING THE SAMPLES

Samples should be placed in a refrigerator at once, and a temperature of 35 to 40° F. should be maintained until they are taken out for scoring. Samples should be protected from strong odors in the storage room, and from dirty water, leaking milk, or careless handling.

ARRANGEMENT OF SAMPLES FOR JUDGING

In each milk contest, four bottles are submitted in each entry. One bottle is used for visual examination of sediment before being opened; it is then opened and samples are taken for bacterial count. From the second bottle, examinations are made for acidity, fat and solids-not-fat.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF DAIRY INDUSTRY

SCORE CARD FOR MILK AND CREAM

(Approved by The American Dairy Science Association)

Place .....

Class ..... Exhibit No. .....

	Perfect Score	Score Allowed	Remarks
Baeteria	45		Baeteria found per cubic centimeter .....
Flavor and odor	25		Cowy, bitter, feed, flat, strong, cooked .....
Sediment	10		.....
Temperature (street samples) *or* Acidity (prepared samples)	15		Degrees ..... *or* Per cent .....
Bottle and cap	5		Bottle ..... Cap .....
Total	100		

Exhibitor .....

Address .....

(Signed) .....

.....

.....

Judges.

Date .....

DIRECTIONS FOR SCORING

Bacteria per Cubic Centimeter—Perfect Score, 45

	Points		Points		Points
500 and under..	45.0	10,001–11,000.....	42.8	25,001–30,000.....	36.1
501– 1,000.....	44.9	11,001–12,000.....	42.5	30,001–35,000.....	35.1
1,001– 1,500.....	44.8	12,001–13,000.....	42.2	35,001–40,000.....	34.1
1,501– 2,000.....	44.7	13,001–14,000.....	41.9	40,001–45,000.....	33.1
2,001– 2,500.....	44.6	14,001–15,000.....	41.6	45,001–50,000.....	32.1
2,501– 3,000.....	44.5	15,001–16,000.....	41.2	50,001–55,000.....	30.1
3,001– 3,500.....	44.4	16,001–17,000.....	40.8	55,001–60,000.....	28.1
3,501– 4,000.....	44.3	17,001–18,000.....	40.4	60,001–65,000.....	26.1
4,001– 4,500.....	44.2	18,001–19,000.....	40.0	65,001–70,000.....	23.1
4,501– 5,000.....	44.1	19,001–20,000.....	39.6	70,001–75,000.....	20.1
5,001– 6,000.....	43.9	20,001–21,000.....	39.1	75,001–80,000.....	17.1
6,001– 7,000.....	43.7	21,001–22,000.....	38.6	80,001–85,000.....	13.1
7,001– 8,000.....	43.5	22,001–23,000.....	38.1	85,001–90,000.....	9.1
8,001– 9,000.....	43.3	23,001–24,000.....	37.6	90,001–95,000	5.1
9,001–10,000.....	43.1	24,001–25,000.....	37.1	95,001–100,000....	1.1
				Over 100,000.....	0

Flavor and Odor—Perfect Score, 25

Deduct for disagreeable or foreign odor or flavor according to conditions found. When possible to recognize the cause, describe it under "Remarks."

Sediment—Perfect Score, 10

Examination for sediment may be made by means of a sediment tester, and the resulting cotton disks compared with standards; or the sediment may be determined by examination of the bottom of the milk or cream in the bottle. In the latter case allow the milk or cream to stand undisturbed for at least an hour before the examination. Raise the bottle carefully in its natural upright position until higher than the head. Tip slightly and observe the bottom of the milk or cream with the naked eye or with the aid of a reading glass. The presence of the slightest movable speck makes a perfect score impossible. Make further deductions according to the quantity of sediment found. When possible describe the nature of the sediment under "Remarks."

Temperature (Street Samples)—Perfect Score, 15

°F.	Points	°F.	Points	°F.	Points
40 and below.....	15.0	47.....	13.2	54.....	8.0
41.....	14.8	48.....	12.8	55.....	7.0
42.....	14.6	49.....	12.4	56.....	6.0
43.....	14.4	50.....	12.0	57.....	5.0
44.....	14.2	51.....	11.0	58.....	3.0
45.....	14.0	52.....	10.0	59.....	1.0
46.....	13.6	53.....	9.0	60 and over.....	0

OR

Acidity (Prepared Samples)—Perfect Score, 15

	Points		Points		Points
0.18 per cent and less.	15	0.2 per cent.....	12	0.22 per cent.....	5
0.19 per cent.....	14	0.21 per cent.....	9	0.23 per cent.....	1
				Over 0.23 per cent....	0

Bottle and Cap—Perfect Score, 5

Make deductions in score for dirty or chipped bottles; and for caps which do not cover the lips of the bottles, or do not fit properly in the cap seats.

Note.—Any sample failing to comply with the legal standard for bacteria, fat, or solids not fat, shall be debarred from competition.

The third bottle should be scored for appearance, then opened and judged for flavor and odor. The fourth bottle is held in reserve for use in case of mishaps during any of the tests.

STUDENTS' JUDGING CONTESTS

The following points are considered in students' judging contests.

MARKET MILK

Item.	Perfect Score.
Flavor and odor	25
Sediment	10
Bottle and cap	5
Total	40

Samples are selected before the contest. Usually ten lots of market milk are selected. Each lot should be uniform and should contain enough bottles to supply the judges and each group of students with a fresh, unopened bottle.

Before the contest, the judges score a bottle of milk from each lot, recording the numercial score and criticisms. These ratings are later used as a standard to mark the contestants' scorings. To acquaint the contestants with the judges' standards, two additional samples of milk are scored. These are displayed with the judges' criticisms, and the students have an opportunity to examine them before the contest starts.

METHOD OF SCORING MILK

The following items are scored in milk contests, but are not considered in Students' Judging Contests.

Bacteria.—Standard methods of bacteriological analysis of milk are used. Dilutions of $\frac{1}{100}$ and $\frac{1}{1000}$ are usually made. Plates are incubated for forty-eight hours at 37° C. Ratings are given in accordance with instructions on the back of the score card.

Acidity.—Acidity is determined by titrations against an alkali solution, with phenolphthalein as an indicator. In milk contests, 50 c.c. of milk are usually taken for titration. Tenth-normal sodium hydroxide is used for the alkali.

Table 24 gives the acidity when 50 cubic centimeters of milk are titrated against tenth-normal alkali.

POINTS SCORED IN STUDENTS' JUDGING CONTESTS

Order of Scoring.—The milk should be cold during the examinations for sediment and bottle and cap, but should be warmed before

examination for flavor and odor. Students should be instructed to score sediment first, bottle and cap next, and flavor and odor last.

TABLE 24

Determination of Acidity in Milk

(When 50 c.c. of milk are used)

Cubic Centimeters NaOH n/10.	Per Cent Acidity as Lactic Acid.	Cubic Centimeters NaOH n/10.	Per Cent Acidity as Lactic Acid.
4.0	0.072	11.0	0.198
4.5	.081	11.5	.207
5.0	.090	12.0	.216
5.5	.099	12.5	.225
6.0	.108	13.0	.234
6.5	.117	13.5	.243
7.0	.126	14.0	.252
7.5	.135	14.5	.261
8.0	.144	15.0	.270
8.5	.153	15.5	.279
9.0	.162	16.0	.288
9.5	.171	16.5	.297
10.0	.180	17.0	.306
10.5	.189	17.5	.315

Sediment.—Sediment disks are prepared for the students to score. Fig. 34 presents a series of standard sediment disks showing the scores for varying amounts of sediment in one pint of milk.

A perfect score for sediment is impossible if as much as one single speck of sediment is present.

Suggested Scores on Sediment in 1 Pint

10 ..... No perceptible trace.	9.7..... 4 to 6 tiny particles.
9.9..... 1 to 2 tiny particles.	9.6..... 6 to 8 tiny particles.
9.8..... 2 to 4 tiny particles.	9.5..... 8 to 10 tiny particles.

Cuts as fine as $\frac{1}{10}$ point may be made for variations between the sample grades illustrated.

More severe cuts are made for large pieces of sediment, cow hairs and other débris which might easily have been strained out. Students should describe the character of the sediment, wherever possible.

Bottle and Cap.—A perfect score for bottle and cap is given when the bottle is in good condition, filled full without leakage, and closed with some device which adequately protects the contents and the mouth of the bottle. Dirty or chipped bottles are cut $\frac{1}{2}$ to 1 point, and some-

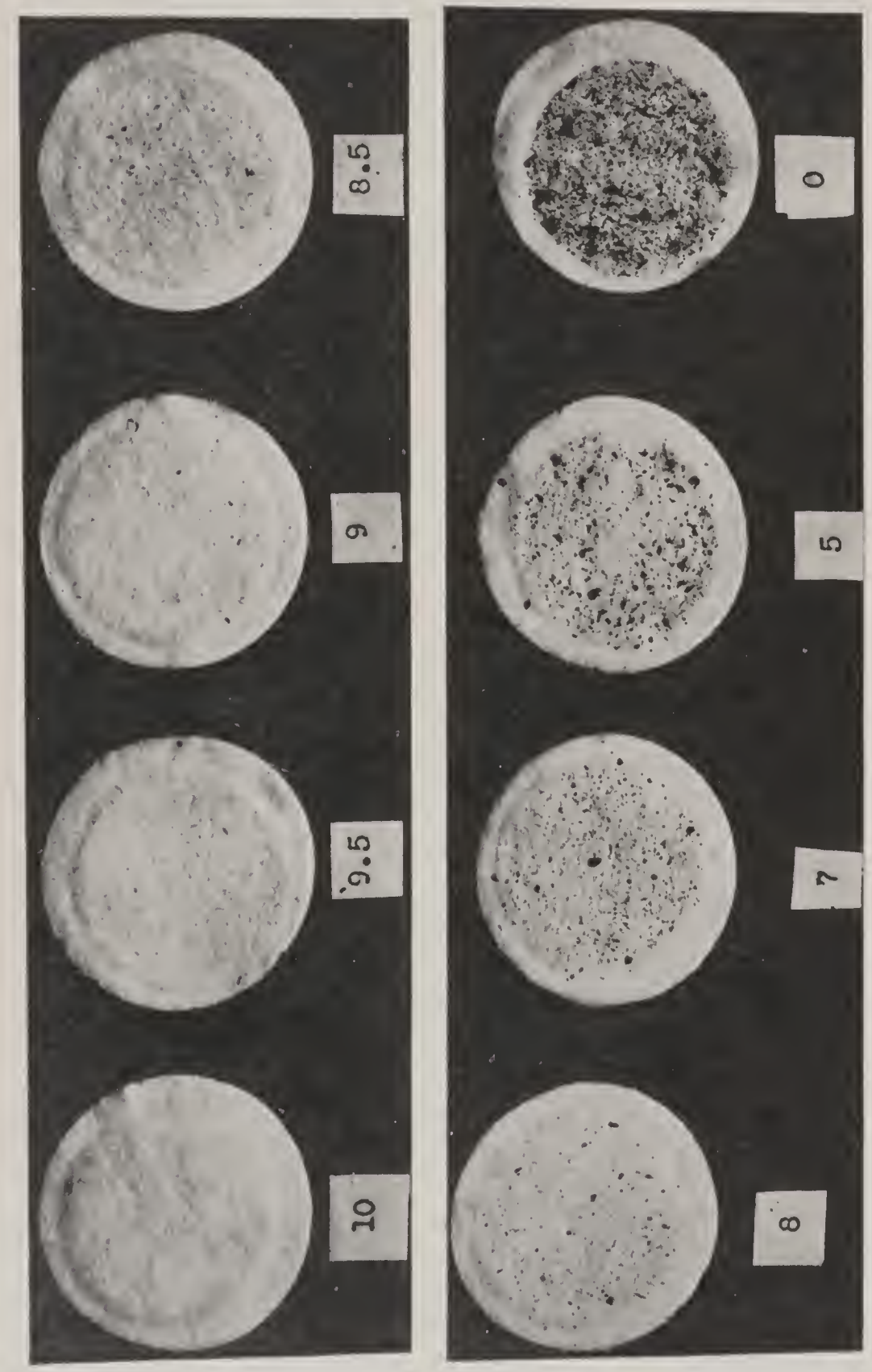


FIG. 34.—Standard disks for scoring sediment.

times more, depending upon the extent of the defect. If paraffin is spilled on the body of the bottle, cuts of $\frac{1}{10}$ or $\frac{2}{10}$ may be made.

Caps which are leaky because of imperfect fitting, or defects in cap or cap seat, are usually cut from $\frac{1}{4}$ to $\frac{1}{2}$ point.

Bottles which are not filled to within half an inch of the cap are cut for not being full. An entire point is usually deducted if the shortage amounts to 2 inches. Lesser cuts are made for smaller deficiencies.

FIG. 35.—Various devices for protecting the milk bottle mouth from contamination.

If wire or metal fasteners come in contact with the milk, no cut is made unless such metal parts are rusted, in which case $\frac{1}{10}$ point is deducted.

Failure to protect the cap and pouring lip of the bottle warrants a cut of 1 point. Thus, if only the ordinary fiber disk or cap is used, the score for bottle and cap cannot be more than 4 out of a possible 5.

Various methods may be used to cover the lip of the bottle. Metal crowns or tightly fitting, heavy fiber, outer coverings are allowed a perfect score. Paraffin or heavy, waterproof paper or cloth, neatly and securely fastened over the bottle mouth, are considered perfect. If paraffin is not applied so as to completely cover the cap and bottle lip, deductions of from $\frac{1}{10}$ to $\frac{1}{2}$ (usually $\frac{1}{4}$) point should be made.

Sometimes a double cap is used. This consists of an ordinary cap with a larger cap fastened to it, and projecting over the lip of the bottle. While such caps give some added protection, they are not water-tight and for that reason are usually cut $\frac{1}{2}$ point, unless protected by an outside covering.

In scoring bottle and cap, the student should bear three things in mind: the entire appearance should be neat and attractive; no milk should leak out; and no dust or water should touch the cap or the mouth of the bottle.

SUGGESTED CUTS ON BOTTLE AND CAP

Bottle not full	0.25 to 1.00
Dirty bottle	.50 to 2.00
Cap poorly seated or leaky (if uncovered)	.10 to 1.00
Chipped lip	.10 to .50
Pouring lip unprotected	1.00
Pouring lip partially protected	.25 to .75
Cap covering loosely fastened	.25 to .50
Cap covering non-waterproof	.25 to .75

Flavor and Odor.—Before milk is scored for flavor and odor, the bottles should be placed in warm water until the milk attains a temperature of 95 to 100° F. Faint odors are more easily detected at this temperature than when the milk is cold.

Scoring should be done in a room free from odors. Thoroughly mix the contents of the bottle by shaking and tipping. Remove the outer cover and cap, and pour part of the contents into a clean cup, glass or beaker. Apply the nose at once to the open bottle mouth, to get any odor which may be present; then mix the milk by pouring back and forth a number of times. Flavors are observed by tasting milk from the beaker or glass, a small sample being sufficient. The milk remaining in the glass should not be poured back into the bottle. It is well to sip the milk slowly, allowing it to remain in contact with the tongue for some time. During the process, the mouth should not be kept tightly closed, as this tends to decrease the sensibility of taste.

Glasses or beakers should be thoroughly washed after being emptied of each sample. The student may clear his mouth with water or by chewing a piece of apple.

No definite ratings can be given that will cover all varieties and intensities of flavor and odor, as constant practice and observation are necessary to master all these details. The same variety of flavor may receive different scores because of variation in intensity.

The most common off flavors and odors found in milk and cream are those produced by certain feeds, by the absorption of foul odors from the stable, by the presence of foreign substances in the milk, and by bacterial action. If the flavor is very bad, it can usually be definitely classified. Points are deducted for flavors resulting from strong feeds, and for cowy, strong, bitter, sour, or other off flavors.

General Guide for Scoring Flavor and Odor

Flavor.	Milk and Cream.	Description.
Excellent	23 and above	Supreme quality.
Good	21 to 23	Lacking special high flavor, flat, very slight feed, slightly cooked.
Fair	18 to 21	Cooked, feed, salty, slightly cowy, slightly metallic.
Poor	12 to 18	Strong feed, weedy, bitter, strong, musty, cowy, metallic, slightly rancid (cappy or cardboard).
Bad	12 to 0	Rancid, strong cowy, high acid.
	0	Sour, putrid or any flavor sufficiently strong to render the milk unfit for market milk purposes.

Cream is scored in the same way as milk.

Each student is rated on his ability to detect abnormalities and to describe them correctly. His score on each item should agree with the official score. Furthermore, he should be able to describe the defects found.

Contest ratings are based both on actual numerical scores and on criticisms. Scores and criticisms are graded separately; but the grades are combined to form the total grade of each contestant.

The following method of rating is being used:

Score.—*Flavor and Odor.*—The contestant's score on flavor will be given a grade expressed by the difference between his score and the official score.

Sediment.—Scored as for flavor.

Bottle and Cap.—Scored as for flavor.

Placing.—The score for placing shall be determined by the sum of the differences in the position of the contestant's samples and the official placing.

Total scores only will be taken for consideration. *Example.*—If the contestant places the highest scoring example fourth, he would lose 3 points; the second highest seventh, he would lost 5 points, and so on for all ten samples. The sum of the differences shall be the score on placing.

Criticism.—When the score of flavor and odor, or of bottle and cap, is cut, a criticism shall be checked. In grading criticisms the maximum cut for each item shall be 1 point.

Determining the Grade.—A contestant's grade shall be found by adding the differences on scoring, placing and criticism. The contestant having the lowest score shall be first. A team's grade is the sum of the grades of its members. The teams are placed according to their grades, the team having the lowest score wins first place.

When two or more contestants tie, or teams have the same grade, the awarding of the medals shall be decided by determining which has the highest score on flavor and odor, then on sediment, then on bottle and cap. If no prize is involved, the placing shall be given as a tie.

REFERENCES

Kelly, Posson, Babcock and Leete, How to Conduct Milk and Cream Contests. U. S. Dept. Agri., Circ. 384.

CHAPTER XI

THE COST OF MILK PRODUCTION

IMPORTANCE OF STUDY

A THOROUGH knowledge of the cost of milk production is essential to all connected with the dairy industry. Until within the last few years, there were few data on the subject, and even now there is an opportunity for greatly increasing our present knowledge to cover wide variations in climate, feeding practices, herd management, etc. A complete understanding of costs is necessary in order that the dairyman may know his financial status, and the purchaser of dairy products may be informed as to the fairness of prices.

If cost studies are made on groups of farms, operating under similar conditions, the dairyman has a measuring rod for his own efficiency. Such a study will enable him to see whether or not he is producing milk as economically as his neighbor, and will show the particular point or points where he can reduce expenses.

TYPE OF STUDY

In general, cost studies may be divided into two systems: that which considers the whole farm as the unit, and that in which the dairy proper is separated from the rest of the farm.

The former system is obviously applicable only to those farms where dairy products are the sole output. Even in such cases, results may be very misleading. For instance, a farmer might be growing his feed at a profit sufficient to wipe out any loss made by turning this feed into milk through the cows. The entire business would then show a profit; whereas, if the dairy alone had been considered, a loss would have been shown.

Practically all cost accounting at this time utilizes the second system, in which only the land devoted to the dairy is considered. This includes pastures, yards and grounds occupied by dairy buildings. The farm buildings are prorated according to the space actually used by the dairy herd and dairy operation. Dairy equipment only is included, no con-

sideration being given to other farm implements. The cows are charged with all feeds (including homegrown) at market prices on the farm, and they are credited with milk, calves and manure at market values.

METHODS OF OBTAINING DATA

Using the dairy as a unit, there are two distinct methods of obtaining the necessary data; these may be called the "survey" method, and the "direct observation" method. In the survey method, the investigator calls upon dairymen and secures from them an estimate of the dairy expenses and receipts over a given period of time, which may be a week, a month or a year. The farmer estimates the quantity and value of feed used, time spent in dairy operation, amount spent for upkeep, repairs, supplies, etc., and other items entering into the calculations.

In the direct observation method, actual records are kept for periods of a year or more. These records may be kept by the dairyman himself, or by an investigator employed for that particular purpose. The survey method allows each investigator to obtain reports from more farms, in a given length of time, than does the direct observation method. Its proponents believe that inaccuracies in estimation equalize each other when many reports are combined; that is, if some farmers overestimate, others will underestimate, so that the average of all estimates will present a true picture. While this is generally true, it may not hold good as regards milk production costs. Take, for example, the question of labor. The farmer knows that feeding, milking, care of the milk, etc., take a certain amount of time from start to finish. But, during this time, actual dairy labor is often stopped for a few minutes while the farmer attends to other things. This might lead to an overestimation of labor requirements for milk production.

The direct observation method is quite accurate, but an investigator can cover only about twenty to twenty-five farms if monthly visits are made, and records properly kept.

THE DIRECT OBSERVATION METHOD

The United States Department of Agriculture, Bureau of Dairy Industry, and many of the Agricultural Colleges have used the direct observation method of obtaining the requirements for milk production. The following paragraphs describe the methods employed by the United States Department of Agriculture. Some of them are taken direct from publications issued by that Department.

In cost of milk production observations, unit requirements rather than monetary terms should be used so far as possible. The results can

then be applied at other times and in similar sections, by using current local prices for feed, labor, etc.

SELECTION OF FARMS

In selecting a group of farms for study, several points should be taken into consideration. It is very desirable that all herd-owners should be members of a cow-testing association. In this way an accurate check is kept on feed and milk records.

The farms should be typical of the section and should be so close together that the investigator loses little time in going from one to another.

A selection should be made of dairymen who are interested in the work, and who will continue throughout the proposed period.

OBTAINING THE ACTUAL DATA

The field agents record in detail all available information relative to the dairy business, including the amounts and classes of labor, feed, bedding, pasture cost, amount of milk sold and used on the farm, and current expenses for the month. Accurate data on calves and first-hand information on methods of handling manure are systematically collected.

If records on every dairy are obtained regularly every month, the influence of unusual circumstances at the time of any particular visit is lessened; and if records of all the herds for each month are used, complete data for each month, season and year are obtained. Data are usually obtained for two entire years, in order to compare one year with the other in the same section and to increase the amount of data for study.

At the beginning and end of each year, the field agent takes an inventory of the dairy buildings, livestock, and equipment used in the care of the herd and its products. On his regular monthly inspection tour, he arrives at the first farm of a group in time to observe the first labor operations connected with the evening chores. With watch in hand he notes and records the minute each labor operation connected with the dairy is begun and ended. The labor operations during the next day are recorded in the same manner.

The field agent also verifies the records of feed that are being consumed on the inspection day, recording the kind, quantity, cost, and description of each, comparing them with the quantities recorded by the cow tester in the cow-testing-association books. The quantity of milk sold and the receipts for each month are obtained, and the whole

milk used by the proprietor and his help, or fed to calves which were being raised, is measured or weighed and used as a basis for determining the amount kept on the farm during the month.

Each dairyman keeps an itemized account of expenses which were incurred between the monthly visits, and these items are recorded by the field agent. A monthly record is also kept of the purchase or sale of cows, calves, and hides. Outside bull service and other miscellaneous information relating to the herd are recorded. The field agent also notes the condition and methods of handling manure and reports it each month.

When all the labor operations about the dairy have been completed for the day at the first farm, the field agent drives to the next farm in time to observe the labor operation connected with the evening chores.

SEPARATING SEASONS

Winter and summer conditions have a marked influence on the principal factors entering into the cost of milk production, and milk prices are often set for seasonal periods. For these reasons it is desirable to compute the requirements for milk production separately for summer and winter. In general, the winter season is usually considered to extend from November to April, inclusive, while the summer season includes the months May to October. Climate and feeding practice influence this arbitrary division.

ITEMS CONSIDERED

The following debits and credits should be considered in studying the cost of milk production:

Debits:

- Feed
  - Concentrates
    - Purchased, pounds
    - Home grown, pounds
  - Non-commercial roughages, pounds
  - Commercial roughage
    - Legume, pounds
    - Carbohydrate, pounds
  - Silage, and other succulent roughage, pounds
  - Pasture, acres
  - Bedding, pounds
  - Hauling and grinding concentrates, dollars
- Labor
  - Human
    - Owner
    - Hired help
    - Women and children

    .... hours
  - Horse, hours
  - Managerial ability

- Other Charges
  - Building charges — Interest, depreciation, taxes
  - Equipment charges — Insurance and repairs
  - Supplies
  - Motor truck or other hauling charges
  - Herd charges
    - Interest
    - Depreciation
    - Taxes
    - Insurance
    - Cost of keeping bull
  - Miscellaneous
    - Medicine
    - Disinfectant
    - Veterinary fees
    - Cow-testing dues, etc.

Credits:

- Milk sold, used or fed to livestock, pounds
- Calves, number
- Manure, pounds

EXPLANATION OF ITEMS

The items considered in the cost of milk production are defined as follows in U. S. Department of Agriculture Bulletin 923. (1) They are slightly modified for use here.

Feed.—The quantities of the different kinds of feed are obtained from actual weights made by the cow tester during one full day of each month. The quantities are also checked frequently by the field agent.

"Concentrates" is a term applied to grains and to manufactured by-products suitable for feeding. The concentrates are low in fiber and contain a large amount of nutritive material in a relatively small bulk.

"Home-grown grains" consist of concentrates commonly grown on the farm or in the locality where fed.

"Non-commercial dry roughage" applies to corn stover, corn fodder and other dry, coarse feeds for which price quotations are not given in the trade papers. The term is also applied to hay that is so foul with weeds or so damaged in curing as not to be readily salable.

"Leguminous roughage" includes alfalfa, clover, cowpea, soy bean, and other legume hays when pure, or when so slightly mixed with grasses as not materially to affect the protein content.

"Commercial carbohydrate roughage" includes all commercial hays except those classified as leguminous roughage.

Pasture.—The pasture cost includes the interest on the value of the land, the general cost of maintaining the fences, and such other items as seeding, cutting weeds, and repair and maintenance of watering troughs. The value of the land is obtained by subtracting the value of the improve-

ments from the total value of the farm. The cost of pasture is distributed over the six summer months on a percentage basis. The percentage allowed for each month on each farm is estimated as nearly as possible in proportion to the condition of the pasture and the quantity of feed the herd receives from the grass each month.

Labor.—The hours of labor are obtained by actually timing the various labor operations performed about the dairy, during one entire day each month; this time is multiplied by the number of working days in that month, plus the hours of work done on Sundays.

Other Costs.—The " other costs " charged against the production of milk do not include the interest, taxes, and similar items against the entire farming enterprise, but cover only the dairy's share of the buildings and equipment.

Buildings.—Interest is figured at the customary rate of 5 per cent on improved real estate, on the inventory value taken at the beginning of the year. The annual depreciation charge is obtained by dividing the first inventory by the number of years it is estimated the buildings would remain in a usable condition. The annual cost of painting and repairs is computed. Slate roofs, because of their long life and durability, make the depreciation lower on many of the buildings. Taxes and insurance premiums are obtained by examination of the individual tax records and insurance premium receipts. Annual repairs are included in the general charge against the buildings. The expense for buildings charged against the dairy is in proportion to the space used for it.

Equipment.—An inventory is taken at the beginning and end of each year, 6 per cent interest being charged on the first inventory value. The difference between the first inventory, plus equipment purchased, and the inventory taken at the end of the year, plus equipment sold, constitutes the depreciation. A record of all repairs on equipment is kept by the dairyman and given to the field agent each month. Miscellaneous supplies, such as strainer cloths, washing powder, brushes, gasoline, and oil for running machines, are charged at cost.

Herd.—Each cow and bull is inventoried at the beginning of each year at the market value, and to this inventory is added the value of animals entering the herd during the year. Interest is figured at 6 per cent. Each grade cow purchased or sold is recorded at the price paid.

As the requirements for producing milk are the same with a pure-bred cow as with a grade cow of equal productive capacity, it becomes apparent that the greater value of the former is due to the value of her offspring and not to the value of her milk. Since the purpose of the study is to deal with the requirements for producing milk, raising pure-breds must be considered as a separate business. In order to avoid the

influence of the pure-bred business upon the requirements for producing milk, pure-bred cows are given the same value as grade cows of the same productive capacity and pure-bred calves given corresponding grade values.

Death losses are taken care of in the difference in inventories. At the end of the year, the inventory value of each animal in the herd takes into consideration any increase or decrease in value over the first inventory. To the second inventory is added the value of cows or hides sold during the year. The difference between these amounts constitutes the depreciation or appreciation.

The taxes are obtained directly from the township records, and where insurance is carried, the amount of the premiums is obtained from the receipts.

Such miscellaneous items as veterinary services, medicines, disinfectants, and cow-testing-association dues are the sum total of money actually paid out, as shown by the monthly records of the individual herds.

The feed, labor, and other costs for keeping the herd sires are placed under herd charges.

Credit for Calves and Manure.—*Calves.*—Most of the heifer calves are raised or sold to neighbors for raising, while the grade bull calves are usually vealed. The whole milk sucked from the cows is credited to the herd, by crediting the selling price of the calves and not the birth value.

Since the pure-bred cows are given the same value as grade cows of like producing ability, the pure-bred bull calves are credited to the herds at what they would be worth, when four days old, to fatten for veal and the pure-bred heifer calves at the value of grade heifer calves.

Manure.—The credit for manure is figured after the following factors have been taken into consideration: fertilizing constituents in the feeds; quantities of nitrogen, phosphoric acid, and potash not utilized in the bodies of the cows but voided in the manure; the percentage of the total manure dropped in the barn; the percentage of manure saved in the storing and handling; the nitrogen, phosphoric acid, and potash contained in the bedding; and the value of these fertilizing constituents saved in the manure and bedding, all being figured at wholesale prices for commercial fertilizer.

The average credit allowed for manure and bedding, each year, includes the manure from the bulls, and represents what was or could easily have been saved under local conditions. Since the total cost of keeping bulls is charged against the cows, the bull manure is included as a direct credit to the herd.

The fertilizing constituents in 1 ton of average manure and bedding from the cows, during the winter in one section, were estimated to be as follows:

	Pounds per Ton.
Nitrogen	10.8
Commercial phosphoric acid	3.5
Potash	11.9

Without bedding, 1 ton of average winter manure was estimated to contain:

	Pounds per Ton.
Nitrogen	10.7
Commercial phosphoric acid	3.5
Potash	11.4

On the average dairy farm, the commercial value of manure depends upon the use to which it is put. The return in dollars depends upon the increase in the crops raised and the amount received from the sale of these crops. These facts may reduce or increase the value of manure below or above the market price of the fertilizing constituents contained in it.

ILLUSTRATIVE COST TABLES

The requirements for producing milk in seven states were studied by the United States Department of Agriculture. Some of the results obtained in Vermont (1) are here given to illustrate the manner in which such studies may be summarized.

REQUIREMENTS FOR PRODUCING 100 POUNDS OF MILK

Table 25 shows the unit requirements for producing 100 pounds of milk by seasons in Vermont. Such a summary is useful because of the fact that the price of milk is frequently based on 100-pound quantities.

REQUIREMENTS FOR KEEPING A COW ONE YEAR

It is useful to know the requirements for keeping one cow for a year, and to realize the difference in costs between summer and winter periods. Such a tabulation is given in Table 26.

TABLE 25

UNIT REQUIREMENTS, EXCEPT CHARGE FOR MANAGEMENT, FOR PRODUCING 100 POUNDS OF MILK IN WINTER AND IN SUMMER *

Item.	Winter.		Average of Two Winters.	Summer.		Average of Two Summers.
	1916–17	1917–18		1917	1918	
Feed:						
Purchased concentrates..pounds	29.0	30.2	29.6	7.2	9.2	8.1
Home-grown grains..... "	3.2	3.8	3.5	.5	.6	.6
Total concentrates..... "	32.2	34.0	**33.1**	7.7	9.8	**8.7**
Non-commercial roughage "	1.1	1.2	1.2	3.4	.5	2.1
Commercial roughage:						
Carbohydrate hay..... "	108.7	121.4	114.7	10.4	18.2	13.9
Legume hay..... "	18.2	9.4	14.0	2.9	2.6	2.7
Total dry roughage.. "	128.0	132.0	**129.9**	16.7	21.3	**18.7**
Silage and other succulent roughage.....pounds	193.2	189.2	**191.3**	19.9	37.4	**27.8**
Pasture.....acres	.....	.....	.....	.09	.11	**.10**
Bedding.....pounds	10.0	12.5	**11.2**	.....	.....	.....
Hauling and grinding concentrates.....dollars	.....	.....	0.020	.....	.....	0.005
Labor:						
Human labor.....hours	2.7	2.7	2.7	1.9	2.1	2.00
Horse labor..... "	.6	.5	.6	.4	.3	.4
Other costs:						
Building charges.....dollars	0.177	0.174	0.176	0.128	0.140	0.133
Equipment charges and dairy supplies.....dollars	.077	.097	.087	.056	.078	.066
Motor-truck charges..... "	.....	.003	.002	.005	.017	.010
Herd charges—						
Taxes, insurance, veterinary, medicine, disinfectants and cow-testing associations dollars	.048	.066	.056	.035	.053	.043
Interest on cow investment "	.098	.118	.107	.071	.095	.082
Cost of keeping bull..... "	.033	.063	.048	.018	.046	.031
Total of other costs except appreciation and depreciation on cows.....dollars	.433	.521	.476	.313	.429	.365
Depreciation on cows.... "	.....	.166	.079	.....	.133	.060
Appreciation on cows.... "	.....	.....	.....	.....	.....	.....
Total of other costs....dollars	.433	687	**.555**	.313	.562	**.425**

* The summaries of the unit requirements are printed in bold-faced type for convenient reference.

TABLE 26

NUMBER OF COWS, AVERAGE PRODUCTION AND REQUIREMENTS FOR KEEPING A COW, EXCEPT CHARGE FOR MANAGEMENT, BASED ON THE RECORDS OBTAINED FOR THE TWO YEARS 1916–17 AND 1917–1918

Item.	Winter.	Summer.	Entire Year.
Number of cows.....average	819.2	874.6	847.0
Average production.....pounds	2353	2899	5252
Feed:			
Purchased concentrates..... "	696	235	931
Home-grown grains..... "	83	16	99
Total concentrates..... "	779	251	1030
Non-commercial roughage..... "	27	61	88
Commercial carbohydrate hay..... "	2700	403	3103
Commercial legume hay..... "	330	79	409
Total dry roughage..... "	3057	543	3600
Silage and other succulent roughage.....pounds	4502	805	5307
Pasture.....acres	.....	3.0	3.0
Bedding*.....pounds	263	.....	263
Hauling and grinding concentrates.....dollars	0.47	0.14	0.61
Labor:			
Human labor.....hours	64.2	58.8	123.0
Horse labor..... "	13.7	10.4	24.1
Other costs:			
Building charges.....dollars	4.13	3.87	8.00
Equipment charges and dairy supplies..... "	2.04	1.91	3.95
Motor-truck charge..... "	.04	.30	.34
Herd charges—			
Taxes, insurance, veterinary, medicine, disinfectants, and cow-testing association.....dollars	1.33	1.24	2.57
Interest on cow investment..... "	2.52	2.37	4.89
Cost of keeping bull..... "	1.12	.89	2.01
Total of other costs, except depreciation and appreciation on cows.....dollars	11.18	10.58	21.76
Depreciation on cows..... "	1.86	1.74	3.60
Appreciation on cows..... "	.....	.....	.....
Total other costs..... "	13.04	12.32	25.36

* The small amount of bedding used was partly due to the use of refuse hay and other roughage left in the mangers.

REQUIREMENTS FOR KEEPING A BULL

The cost of keeping a bull or bulls is charged to the dairy herd. Table 27 shows the requirements in Vermont.

TABLE 27

REQUIREMENTS FOR KEEPING A BULL, BASED ON AVERAGES OBTAINED FROM THE EQUIVALENT OF 27.1 BULLS (1)

Item.		Average of Two Winters.	Average of Two Summers.	Average for Year.
Feed:				
Purchased concentrates	pounds	162	104	266
Home-grown grains	"	57	13	70
Total concentrates	"	219	117	336
Dry roughage:				
Non-commercial	"	56	68	124
Commercial carbohydrate hay	"	2894	2717	5611
Commercial legume hay	"	765	234	999
Total dry roughage	"	3715	3019	6734
Silage and other succulent roughage	"	1819	577	2396
Bedding	"	269	.....	269
Pasture	dollars	.....	1.92	1.92
Human labor	hours	22.3	15.4	37.7
Other costs:				
Interest on bull investment	dollars	3.06	3.55	6.61
Bull's share of buildings	"	4.13	3.47	7.60
Total of other costs	"	7.19	7.02	14.21
Appreciation on bull	"	1.09	.99	2.08
Total of other costs less appreciation	"	6.10	6.03	12.13

MANAGERIAL ABILITY

An allowance for managerial ability is justifiable; but, as yet, no equitable method of making such an allowance has been worked out.

Such factors as economical feeding, increased production per cow, size of business and low cost of production must be considered.

Some investigators have added 10 to 20 per cent to the cost of production, to cover managerial ability. Such a method is obviously unfair, because the least efficient man, i.e., the producer with the highest cost, received the largest amount for his ability as manager.

Until a satisfactory formula for managerial ability has been devised, it is better to report the actual cost of production, allowing pay for the manager's labor at the same rate as hired men's wages. An arbitrary sum may then be added to cover managerial ability.

CREDITS FOR CALVES AND MANURE

After the total cost of milk production has been computed, credits for calves and manure must be subtracted to find the net cost. Table 28 shows the credit for calves and manure for each 100 pounds of milk produced in Vermont.

TABLE 28

CREDIT FOR CALVES AND MANURE FOR EACH 100 POUNDS OF MILK PRODUCED (1)

Item.	Winter.		Average of Two Winters.	Summer.		Average of Two Summers.
	1916–17	1917–18		1917	1918	
Credit for calves..number	0.024	0.026	0.025	0.009	0.009	0.009
Credit for manure.pounds	370	394	382	46	68	56

Table 29 shows the credits for calves and manure per cow per year.

TABLE 29

CREDITS FOR CALVES AND MANURE PER COW PER YEAR IN VERMONT

Credits.	Winter.	Summer.	Year.
Number of calves	0.58	0.27	0.85
Manure saved.....tons	4.5	0.8	5.3
Nitrogen in manure.....pounds	49.6	8.7	58.3
Phosphoric acid in manure..... "	16.4	2.9	19.3
Potash in manure..... "	54.9	9.3	64.2

It should be noted that credit was allowed only for the manure saved.

PERCENTAGE COMPARISON OF COST FACTORS

It is interesting to note the part that each cost factor represents in the total cost of milk production. This relationship will vary greatly, as each separate factor is subject to variation which may not affect the others. For instance, in times of high feed prices, feed cost may represent a considerably higher percentage of the total cost of production than in normal times.

The difference in cost between summer and winter is also instructive. These relationships and their seasonal variations in Vermont, during the years 1916–1918, are shown in Table 30.

TABLE 30

PER CENT OF THE 2-YEAR COST OF MILK PRODUCTION REPRESENTED BY FEED, LABOR AND OVERHEAD AND OTHER COSTS (1)

Cost Item.	Average of 2 Winters. Per Cent.	Average of 2 Summers. Per Cent.	Average of 2 Years. Per Cent.
Feed and bedding	39.0	10.4	49.4
Pasture	.....	5.5	5.5
Labor	10.8	10.2	21.0
Other costs except herd inventory variations	10.3	10.4	20.7
Total cost except herd inventory variations	60.1	36.5	96.6
Herd depreciation	1.7	1.7	3.4
Total cost of production	61.8	38.2	100.0
Credits:			
Calves	3.5	2.0	5.5
Manure	14.9	2.8	17.7
Total for calves and manure	18.4	4.8	23.2

APPLICATION OF FORMULAS

When it is desired to ascertain production cost, prevailing prices in the locality studied are applied to the unit requirements. A simple example will illustrate the method:

Requirements for Producing 100 Pounds of Milk in Winter.	Cost per Unit.	Total Cost.	
Grain, 33 pounds	3¢ per pound	$0.99	
Dry roughage, 130 pounds	1¢ " "	1.30	
Silage and succulent roughage, 190 pounds	0.3¢ " "	.57	
Bedding, 10 pounds	0.4¢ " "	.04	
Labor, human, 2.5 hours	20¢ " hour	.50	
Labor, horse, 0.5 hour	15¢ " "	.08	
Other costs		.55	
Total gross cost		$4.03	$4.03
Credits: Calves, .03 of a calf	$6.00 per calf	.18	
Manure, 382 pounds	.15¢ per pound	.57	.75
Total net cost			$3.28

AVERAGE, MEDIAN AND BULK-LINE COSTS

Milk should be sold at a profit, but the price should be reasonable, so that demand will be stimulated. If profits are too small, dairymen will lessen production and a subsequent shortage may ensue. If prices are too high, consumption may decrease, with a consequent surplus of milk. Milk producers, dealers and consumers are, therefore, intensely interested in milk prices, and there is a constantly growing tendency for all parties to come to a better understanding of the problems involved.

A complete knowledge of the cost of production is an important factor in such an understanding. But when the cost is known, how may a fair price for milk be determined? Obviously, the price cannot be set by the producer having the highest cost, as such a scheme would encourage uneconomical milk production and work a hardship on the consumer. Neither can the price be determined by the low-cost producer, for all other dairymen would suffer a loss.

In some cases the average cost of production has been used as a standard. This means that one-half of the community milk supply must be sold at a loss, or the dairymen producing it must go out of business, thus curtailing the available supply to a dangerous extent.

Economists believe that the " bulk line " method is more advisable. In this method an arbitrary line is drawn on the cost tables, below which the greater quantity of milk is produced. This bulk line is usually so set that it includes from 80 to 90 per cent of the supply. It covers the cost of producing all milk, except that produced at unreasonably high

costs. Table 31 illustrates the difference between the average and bulk line costs, by the presentation of five imaginary dairy farms.

TABLE 31

AVERAGE AND BULK LINE COSTS OF MILK PRODUCTION

Farm.	Cost per 100 Pounds Milk.	Pounds of Milk Produced.	Total Cost of Milk Produced.
A	$1.20	300	$3.60
B	1.50	250	3.75
C	1.60	400	6.40
D	1.90	200	3.80
x— E	2.40	150	3.60 —x
Total	....	1300	$21.15

Line x—x = bulk line.

It will be seen that 1300 pounds of milk are produced at a cost of $21.15, or an average cost of about $1.63 a hundred pounds.

Setting the bulk line at $1.90 as indicated, includes 1150 pounds of milk or slightly over 88 per cent of the total supply. Thus, the average cost is $1.63, while the bulk line cost is $1.90 a hundred pounds. Farmer C, being the producer whose cost is midway between high and low, is sometimes called the "median man," and his cost, $1.60 per hundred pounds, the "median cost."

EXACTNESS OF COST STUDIES

While cost studies such as have been described are accurate, there are certain rather intangible factors which should be considered in interpreting them. Women and children are credited with wages which they unquestionably earn; but often their labor would be unsalable, coming, as it does, at odd times, as after school and between other jobs. In addition, certain roughages, which might not find a ready sale, are charged to the dairy. Milk production also furnishes a profitable employment during the winter for farm hands employed on a yearly basis.

CAN PRODUCTION COST GOVERN SELLING PRICE?

While it is desirable for milk producers to receive cost of production plus a reasonable profit, this cannot always be done. In the final analysis, price will depend largely upon market demands; therefore, the price of milk cannot be based entirely on the cost of production. But the producer can determine whether or not the market price for milk warrants continued production.

In other words, market demand regulates price; and the margin between price and cost of production regulates supply. It is useless for dairymen to ask a high price for milk if the market will not absorb the product. These statements, of course, apply only to open markets where there is free and unrestricted competition.

These being the facts, the advantages of the bulk line method of price estimation is apparent. The demand and available supply can be estimated rather accurately, and the bulk line price may then be applied to meet the needs of the particular case. For instance, if the market will consume only 70 per cent of the supply, the bulk line may be set at the price under which approximately 70 per cent of the milk is produced. If supply does not meet demand, it may be necessary to raise the bulk line to 90 or even 100 per cent.

IMPORTANCE OF INDIVIDUAL STUDIES

Great care should be exercised in attempting to apply cost formulas in other locations than where the studies were made. It is far better to conduct studies in the exact place where the information is necessary, as in this case there can be no criticism of the results.

REFERENCES

(1) Bain, Posson and Hotis, Unit Requirements for Producing Market Milk in Vermont. U. S. Dept. Agri. Bul. 923.

Larson and Putney, Dairy Cattle Feeding and Management.

Bain, Braun and Gannon, Unit Requirements for Producing Market Milk in Eastern Nebraska. U. S. Dept. Agri. Bul. 972.

Bain and Posson, Requirements and Cost of Producing Market Milk in Northwestern Indiana. U. S. Dept. Agri. Bul. 858.

Bain, Braun and Wood, Unit Requirements for Producing Market Milk in Southeastern Louisiana. U. S. Dept. Agri. Bul. 955.

Bain and Braun, Unit Requirements for Producing Milk in Western Washington. U. S. Dept. Agri. Bul. 919.

Combs and Bain, A Study of the Factors Involved in Producing Milk in North Carolina. North Carolina Dept. Agri., Vol. 41, No. 5, Whole No. 266.

Hopkins, The Relation of Size of Dairy to Economy of Milk Production. Delaware College Exp. Sta. Bul. 118.

Green, Wood and Ragsdale, Milk Production Costs and Milk Prices. Missouri Agri. Exp. Sta. Bul. 156.

Grady and Bugby, Dairy Production in Ohio. Ohio Agri. Exp. Sta. Bul. 334.

Pearson, The Cost of Milk Production Computed on the Year Basis. University of Illinois, Agri. Exp. Sta. Bul. 216.

Peck and Boss, The Cost of Milk Production. University of Minnesota Agri. Exp. Sta. Bul. 173.

Anderson and Riddell, Studies in the Cost of Market Milk Production. December, 1916, Michigan Agri. College Exp. Sta. Bul. 277.

Cooper, Bennett and Church, A Study in the Cost of Producing Milk on Four Dairy Farms, Located in Wisconsin, Michigan, Pennsylvania and North Carolina. February, 1917, U. S. Dept. Agri. Bul. 501.

App. Farm Profits and Factors Influencing Farm Profits on 460 Dairy Farms in Sussex County, New Jersey. July, 1917, New Jersey Agri. Exp. Sta. Bul. 320.

Story and Tubbs, The Cost of Producing Market Milk in 1916–17 on 212 Vermont Farms. September, 1917, University of Vermont and State Agri. College Bul. 209.

Riddell and Anderson, Studies in the Cost of Milk Production, No. 2. January, 1920, Michigan Agri. College Exp. Sta. Bul. 286.

Munger, The Cost of Producing Milk. January, 1921, Iowa State College of Agri. Exp. Sta. Bul. 197.

Peck, Methods of Conducting Cost of Production and Farm Organization Studies. November, 1921. U. S. Dept. Agri. Bul. 994.

CHAPTER XII

METHODS OF SUPPLYING CONSUMERS WITH MILK

PRIMITIVE METHODS

When one considers the exacting demands of the consumers of milk and the distance—often as much as 300 miles—that usually separates them from the producer, one begins to realize the difficulties involved in the marketing of this product.

In the old days, when the country was sparsely populated, many families kept a cow of their own, and this practice is also followed in many small towns to-day. Families who did not own a cow procured their supply from a neighbor. Sometimes a producer would drive to town with a few cans of milk and peddle it about the streets. He would often follow a more or less regular route, and the housewife would come to the wagon with her own receptacle to get the milk. This method of milk-marketing was not conducive to a large consumption of milk, and it was often difficult for people to obtain a sufficient supply.

DEVELOPMENT OF THE MILK DEALER

Families who kept their own cows and sold their surplus milk to their neighbors soon saw the opportunity afforded in selling to others, and they began to buy more cows and also to buy milk from other producers. Soon they began to deliver the milk to the neighbors instead of letting them come for it, and gradually they developed regular delivery routes. Others who saw the opportunities in retailing milk bought milk from producers and started milk routes. In this way the milk dealer of to-day was gradually developed.

PRESENT FACILITIES FOR MARKETING MILK

In general, there are now at least three systems of marketing milk.

1. Direct marketing by the producer himself.
2. Indirect marketing through the middleman or milk dealer.
3. Marketing through Producers' Cooperative Associations.

Under the third system the milk may be distributed by the producers' association itself or through the middleman or milk dealer, the latter practice being the most common.

1. The Village Milk Dealer, or Producer-dealer

In most of our smaller towns and villages, practically all the milk is retailed by the producers themselves. The village milk dealer sells the milk from his own cows and sometimes buys some milk from other producers, which he sells with that from his own cows.

Very little equipment is required by the village milkman. The milk is cooled by setting the cans in a tank of water, or it is run over a milk cooler.

The village dealer either delivers the milk to the consumer from the can which he carries on his wagon or he puts the milk into bottles and delivers bottled milk to the consumer. When bottles are used, quite an investment in bottles is required, as the life of the milk bottle is short. The dealer must also have a bottle washer, usually consisting of a tank with a revolving brush. The brush is made to revolve by a steam turbine or it is connected by a belt to a motor or engine. After the bottles are washed, they are rinsed by being immersed in a tank of water. At the best dairies, after the bottles are washed and rinsed, they are put into a closed chamber or sterilizer; live steam is then admitted to the chamber and the bottles are thoroughly steamed. A small steam boiler is required to furnish steam for hot water and for sterilizing the bottles, etc.

Delivery to Consumer.—The village milk dealer delivers milk to the consumers either once or twice a day, the practice of delivering twice a day being quite common in some southern towns. Usually, as soon as the milk is cooled, it is sent out on the delivery route and is all delivered within two or three hours after milking.

2. The City Milk Dealer

As villages grow into large towns, the village milk dealer, finding that he cannot supply the increased demand for milk from his own cows, buys milk from other farmers. The farms located in or near the town gradually become absorbed by the city so that in time the milk supply has to be " shipped " into the city from the surrounding country. The result is that, instead of receiving the milk direct from the producer, as was formerly the custom, the city consumer now receives it from the milkman, known as the milk dealer, or middleman. The milk dealer buys the milk from the producer, has it brought to his plant, where it is pasteurized and bottled, and delivers it to the consumer. For the purpose of preparing the milk for delivery to the consumer, the milk dealer establishes a plant, where he pasteurizes and bottles the milk.

The construction and equipment of milk plants are discussed in Chapter XV.

Functions of the Milk Dealer.—Thus, the milk dealer takes an important part in the marketing of milk. He makes arrangements for buying the milk from the producer and transporting it to the city. He brings it to his plant in the city, pasteurizes and bottles it and finally delivers it to the consumers, in accordance with their needs. The dealer performs a definite service, regularly and against obstacles, and supplies an economic need in the marketing of milk. He delivers the milk to the consumers at a definite time every day in the year, regardless of weather

FIG. 36.—A large city milk plant of expensive construction. Note platform where milk is received and delivery wagons are loaded and unloaded very rapidly.

conditions, and in the quantities and sizes of container desired, rendering his bill at the end of each week or month. He has to carry a large number of accounts on his books and often wait a long time for his pay, regardless of the fact that the producer must be paid promptly.

The dealer makes contracts with producers who are often located 300 or more miles away, for a supply of milk. He must contract for enough, so that he may always be able to supply the varying demands of his customers. For this reason he will have more milk than he can sell during certain seasons of surplus production, and he has to dispose of this surplus by manufacturing it into by-products, such as butter, cheese, etc.

When the producers are located at considerable distances from the

city, the milk dealer often establishes a country receiving station, where the milk from the various farmers is received and cooled before it is shipped to the city. This requires added investment in plants and equipment, as well as additional expense in handling. For short distances, direct shipments are made from the farmers' station to the city.

Country milk-receiving stations are discussed in Chapter XV.

3. Marketing through Producers' Cooperative Associations

Whether milk is distributed by the milk dealer or not, a large proportion of it is marketed through producers' cooperative associations. In some cases organizations of producers or producer-dealers have been formed, plants have been established, and the milk of the members delivered to the consumers by the association. The marketing of milk through producers' cooperative associations is discussed in Chapter XIII.

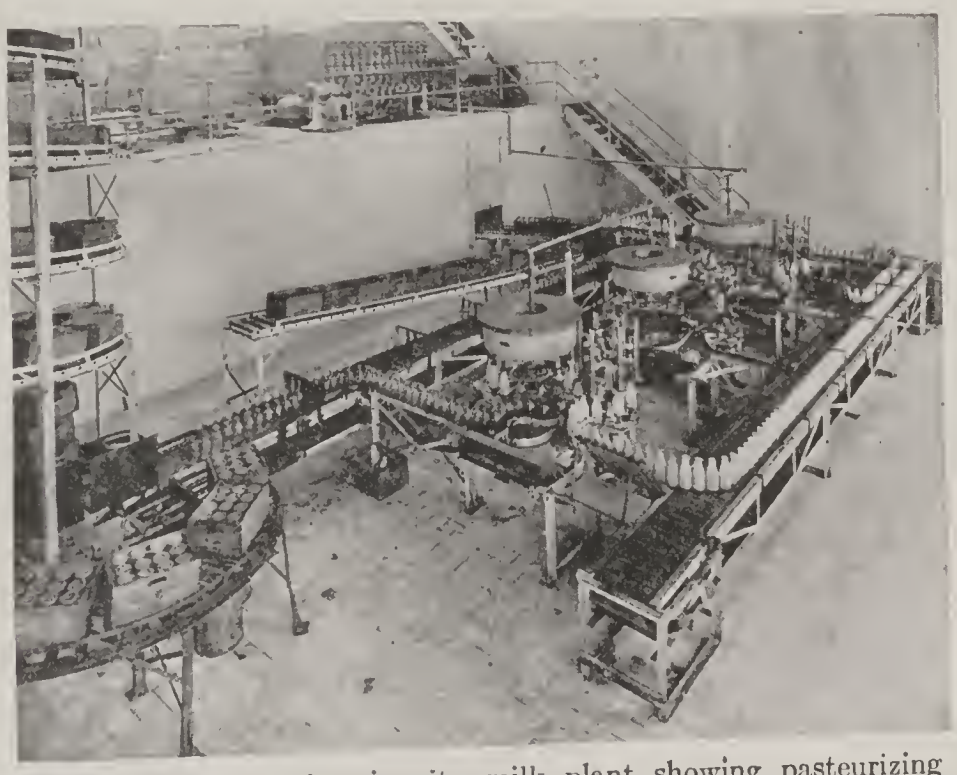


FIG. 37.—Interior view in city milk plant showing pasteurizing and bottling machinery.

METHODS OF BUYING MILK

There are various systems in use by milk dealers of paying for the milk purchased from the producers. Formerly the most common system was to buy by the can, gallon, or quart. This system, however, is not accurate and is fast being superseded by more equitable systems.

Most milk is now bought by weight and on the butterfat basis. As

soon as it arrives at the dealer's plant it is weighed and samples are taken for the butterfat test. The practice of paying for milk on a quality basis is also more common than formerly. Many milk dealers pay the producer premiums for extra quality, based on such factors as bacterial count, temperature, score of the dairy, health of cattle, etc. Such systems encourage the producer to produce high-grade milk.

Buying Milk by Weight.—Although the proportion of dealers who are using the weight system is much larger now than formerly, yet a considerable number of small dealers still use the can measure system of determining the quantity of milk received from the producer. In a recent investigation carried on by one of the authors, some interesting data were obtained which illustrated the inaccuracy of the system of determining the quantity of milk received at the plant by the can measure system alone. Observations were made on a total of 346 shipments of milk, consisting of 1102 cans. The cans of milk were examined on arrival at the plants, before they were dumped into the weigh cans. The quantity of milk, by measure, in cans that were not full, was estimated by means of measuring sticks, so that, regardless of the quantity shipped by the producers and the amount lost before the milk reached the plants, an accurate check was made upon the fullness of the milk cans before they were emptied into the weigh cans. Table 32 below, shows the difference between the quantity of milk dumped, as determined by can measure, and the actual quantity received, as shown by the scales.

TABLE 32

DIFFERENCE BETWEEN WEIGHT AND MEASURE

Number of Cans.	Quantity Received According to Can Measure. Gallons.	Weight. Pounds.	Actual Quantity Received, Allowing 8.6 Pounds to the Gallon. Gallons.	Difference.	
				Gallons.	Per Cent.
1102	6185.32	521,910	6068.72	116.60	1.88

Thus the difference for the total quantity of milk received was 116.60 gallons, or 1.88 per cent. This difference was no doubt due primarily to the poor cans that were used. It cannot be expected that dented and battered cans will hold the full amount.

One company handling a little more than 4000 gallons of milk daily decided after several years to buy the milk by weight. Scales were

installed, and the difference between the measure by the cans and the actual quantity of milk received, as shown by the scales, was determined. Table 33 shows that if the plant had bought the milk by can measure it would have paid for more than 2000 gallons of milk above what it actually received in each of the two months. This would have been a loss of more than $600 a month, if milk was worth 30 cents a gallon.

TABLE 33

DIFFERENCE BETWEEN CAN MEASURE AND ACTUAL QUANTITY OF MILK RECEIVED AS SHOWN BY SCALES AT A CITY PLANT

Item.	Milk Received During April. Gallons.	Milk Received During May. Gallons.
Can measure	126,460	138,485
Weight	124,331	135,941
Difference	2,129	2,544

Inaccuracies which result from buying the milk by measure instead of by weight are due principally to the following causes: Cans not filled by producer, milk spilled or leaked in transit, and use of cans not holding the required amount because of dents or other defects.

BUYING PLANS AND METHODS OF ARRIVING AT PRICES

Sales of milk by milk dealers to consumers vary somewhat, being influenced by such factors as weather, temperature, day of week, number of people away, etc. These variations, however, are not great, and it can be safely said that the consumption of milk from week to week is relatively stable. Production, however, varies greatly during the year so that the supply of market milk available does not coincide with the demand. Usually there is a considerable surplus in May and June and a shortage in October and November. Owing to this uneven production of milk and the failure of the production to coincide with fluid milk demands and with the limited unevenness of consumption, it is necessary for the milk dealer to carry at certain seasons of the year

considerable surplus milk which must be disposed of in the form of manufactured milk products.

Table 34 shows the seasonal variation in milk production in four dairy districts in Illinois, and Table 35 shows the seasonal variations in the consumption of milk and cream in the Chicago market in 1922–1926. Fig. 38 shows graphically the relation of purchases to sales of milk for five large Boston distributors in 1922–1927.

TABLE 34

SEASONAL VARIATION IN MILK PRODUCTION IN FOUR DAIRY DISTRICTS OF ILLINOIS * (1)

(Figures are based on total receipts at milk plants and represent percentage of average month during period specified) †

Month.	Chicago, 1925.	St. Louis, 1922–1925.	Peoria, 1926–1927.	Quincy, 1924–1926.
January	89.6	109.5	79.9	99.4
February	86.1	104.8	78.6	95.8
March	99.7	117.5	90.6	106.1
April	100.6	120.5	95.9	108.9
May	119.8	149.0	129.1	123.9
June	119.1	112.8	136.5	109.9
July	108.4	93.1	125.2	106.5
August	99.6	75.6	112.9	99.0
September	91.7	62.3	93.3	86.2
October	96.0	72.8	88.6	86.1
November	90.5	82.4	84.6	85.2
December	98.9	99.7	84.8	93.0
Total volume (pounds) on which percentages are based	647,217,469	117,491,991	69,001,699	15,174,190

* Trend removed. † Not corrected for varying number of days in different months.

A few years ago the flat contract price was the prevailing system of purchasing market milk. The dealer would contract for the entire supply of the producer, and, owing to the relatively low production in the fall months, he would have to make contracts with enough producers to supply the demands of his customers at that time. He would therefore have to carry a considerable surplus during the spring months when production was relatively high. He could, of course, realize on his surplus milk only what it was worth for manufacturing into by-products. Therefore, in most cases, he made his contract price for

TABLE 35

SEASONAL VARIATION IN CONSUMPTION OF MILK AND CREAM IN THE CHICAGO MARKET, 1922–1926 * (1)

(Figures indicate percentage of average monthly sales and are based on an approximate annual distribution of 4 million pounds)

	Milk, Quarts.		Milk, Pints.		Cream, Half-pints.	
	Retail.	Wholesale.	Retail.	Wholesale.	Retail, 22 Per Cent.	Retail, 32 Per Cent.
January....	101.9	94.7	90.6	83.3	104.3	122.7
February...	102.2	95.7	93.0	84.6	103.7	119.7
March.....	102.6	96.1	95.3	85.8	103.7	117.6
April.....	102.0	95.9	98.1	90.7	104.3	124.6
May.....	100.5	96.6	99.8	96.9	102.4	115.9
June.....	101.2	105.8	106.1	111.6	97.3	84.1
July.....	93.3	107.4	103.6	115.9	90.3	62.1
August.....	92.3	109.4	106.6	121.3	87.9	57.1
September..	98.9	108.7	107.2	119.2	96.4	68.6
October....	101.4	101.0	106.9	110.3	100.6	91.5
November..	101.8	96.1	101.1	96.8	103.8	115.9
December..	101.9	92.6	91.7	83.6	105.3	120.2

* Trend removed.

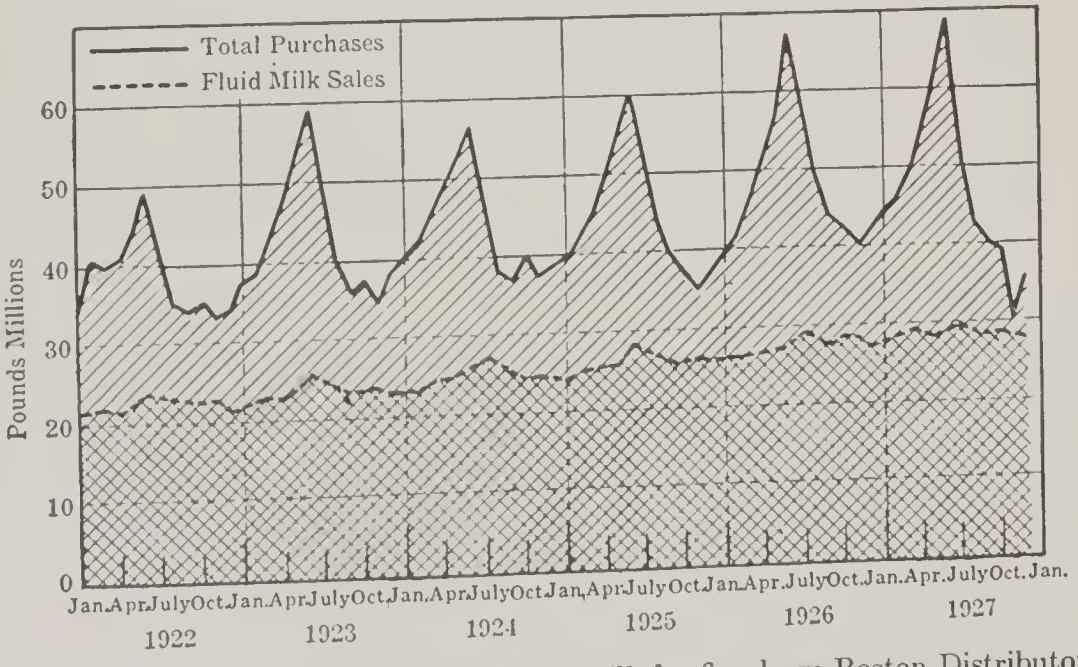


FIG. 38.—Relations of purchases to sales of milk for five large Boston Distributors in 1922–1927. (3)

all milk received low enough to compensate him for any loss sustained on the surplus. In some cases the dealer would determine the amount of the surplus and pay the producer a lower price for all milk which he had to dispose of in other forms than market milk. This system was very unsatisfactory to the producer.

During the last 10 or 15 years more equitable buying plans, based as far as possible on economic laws, have been worked out. This has been to a large degree because of the bargaining power of the producers' cooperative associations which have been organized during the period.

In general, the various buying plans attempt to accomplish the following:

1. Insure a supply of high quality of milk, sufficient to meet the demands of the market at all times.
2. Secure from the dealers prices for milk based on its value in different uses, as fluid milk, cream, butter, cheese, etc.
3. Distribute the payments from the dealers to each producer in accordance with the evenness of his production throughout the year.

In general there are three main plans for buying milk which attempt to carry out the above objects:

1. The basic surplus price plan.
2. The classification or use price plan.
3. The combination plan.

The Basic Surplus Price Plan.—Under this plan the producer is compensated for producing an even volume of milk throughout the year. He is assigned a definite volume of production and for amounts over and in some cases under this basic volume he receives a surplus or lower price. Each producer's basic quantity is usually determined by his average production during the previous October, November, and December, the period of the year when supply and demand most nearly balance. For all milk produced above this basic volume he receives surplus prices. This plan is employed in the Philadelphia and Baltimore milk sheds.

In some markets each producer is permitted to make an estimate of his future production and this becomes his base. For all milk produced above or below this estimated volume he is penalized. This is sometimes called the "contract" plan and is employed by the Connecticut Milk Producers' Association. Each producer signs a contract with the association, stating the quantity of milk he proposes to deliver daily during the next 12 months. Penalties are provided for any excess production above the contracted quantity or for any shortages below the contracted quantity.

Under the basic surplus price plan the actual prices paid are usually

arrived at by negotiations between representatives of the dealers and of the producers. In arriving at the basic or market-milk price, such factors as business conditions, market demands, probable production, cost of production, etc., are considered; while the surplus price is usually based on the market quotations for butter, cheese, etc.

The Classification or Use Price Plan.—This plan recognizes the fact that milk used in different ways has different values. There are at least two classes of milk under this plan. The Connecticut Milk Producers' Association plan, which is a combination of the basic surplus and the use price plan, provides for four classes: Class 1, all milk sold in fluid form; Class 2, milk made into cream that is sold in fluid form; Class 3, milk made into manufactured products, except butter; and Class 4, milk used in making butter. In some markets all milk not used in fluid form is used as cream. In that case only two classes are required. Prices for the different classes are determined by negotiation between representatives of the producers and of the dealers. The price for Class 1 is usually based on market conditions such as total production in relation to the demands for milk in fluid form. Prices for the other classes are based on market quotations for cream, butter, cheese, etc. Records of the sales of the dealers are necessary in order to determine the amounts of milk going into the various classes.

Milk sold in the New York City market through the Dairymen's League Cooperative Association is sold under the use price plan, as is also milk sold in the Boston market through the New England Milk Producers' Association. In the New York market all milk sold under this plan is "pooled." The total payments received from the dealers for all classes of milk sold is divided by the total volume of all the producers selling under the plan to obtain the pool price. Each producer receives the same price for his milk (subject to butterfat and freight differentials) regardless of whether his milk was sold in New York City as fluid milk or held in the country and manufactured into butter or cheese. In the Boston market the price is not pooled as in the New York market. A producer selling to one dealer may receive for his milk a different price from that received by another producer selling under the same plan to another dealer, because the two dealers may have received different proportions of milk that was not sold as fluid milk. If the particular dealer to whom the milk was sold had no surplus, the producer selling to him would receive the full Class 1 price for all milk delivered. If the dealer had a 50 per cent surplus, the producer would get full price for half of his product and the Class 2 price for the other half.

The Combination Plan.—This is a combination of the basic surplus price plan and the classification or use price plan. The milk is sold by

the producers' association in accordance with the classification or use price plan; i.e., the dealers pay the fluid milk price and the surplus prices for the milk received in accordance with the uses that are made of it, whether for fluid milk or for cream or butter. The returns to each individual producer, however, are determined by a method similar to the basic surplus price plan. This plan is used by the Connecticut Milk Producers' Association, and, as before stated, the " basic " amount in that territory is established by the producer's own estimate under his contract.

The New England Milk Producers' Association selling milk to Boston dealers has recently modified its former classification or use price plan so that the returns to the producer depend on the evenness of his year-round production as well as on the use that is made of the milk by the dealers.

The Plans Compared.—The chief objection that might be raised against the basic surplus price plan is that changes in market conditions and demands for milk will not necessarily change the price that a producer will receive for his basic quantity. In some cases this has brought about a modification of the plan, and when there is an increased demand for fluid milk the Class 1 price has been offered to the producers for quantities above their established basic amounts.

The "contract" basic surplus plan used by the Connecticut Milk Producers' Association places upon the producer the responsibility for the quantity he should attempt to produce each month and is more flexible than the basic surplus plans used in the Baltimore and Philadelphis milk sheds, where the basic amount is determined by previous production. Under the "contract" plan the producer is penalized for underproduction as well as for overproduction, whereas under the usual basic surplus price plan he is not penalized for underproduction.

The classification or use plan may not directly bring about a seasonal coordination of production to consumption. This may be accomplished in part, however, by raising or lowering the basic price when there is a relatively small or large surplus over demand for fluid milk. In some markets, also, prices are negotiated each month.

Both the basic surplus price plan and the classification price plan have been successful in certain territories where they have been adopted, but it would not follow that either plan would be successful in some other territory. Either plan must be adapted to the particular conditions of the milk shed in which it operates.

The basic surplus plan which includes the "contract" plan may be modified into the combination price plan if deemed desirable, so that the dealer purchases his milk on the basis of the use that is made of it

while the individual producer is paid in accordance with his established base. This is the plan used by the Connecticut Milk Producers' Association, and the New England Milk Producers' Association plan has been somewhat similarly modified. Under the usual basic surplus plan, however, payments to the producers are on the same basis as are sales to the dealers, and the dealer profits or loses when the amount of milk consumed in fluid form is above or below the basic amount for which he pays Class 1 prices.

REFERENCES

Erdman, H. E., The Marketing of Whole Milk, 1921.

Hilbard, B. H., and Erdman, H. E., Marketing Wisconsin Milk. Wisconsin Agri. Exp. Sta. Bul. 285, 1917.

Parker, H. N., The City Milk Supply, 1917.

Clement, C. E., Milk Plant Operation. U. S. Dept. Agri. Bul. 973, 1922.

Milk Plant Letters, U. S. Dept. Agri.

Milk Price Reports, U. S. Bureau of Agr. Economics.

King, Clyde L., The Price of Milk, 1920.

(1) Brown, C. A., Costs and Margins and Other Related Factors in the Distribution of Fluid Milk in Four Illinois Market Areas. Ill. Agr. Exp. Sta. Bul. 318, 1928.

(2) Metzger, Hutzel, Cooperative Marketing of Fluid Milk. U. S. Dept. Agr. Tech. Bul. 179, 1930.

Bartlett, R. W., Milk Marketing in Pennsylvania. Penn. State Agr. Exp. Sta. Bul. 208, 1926.

(3) Schoenfeld, W. A., Some Economic Aspects of the Marketing of Milk and Cream in New England. U. S. Dept. Agr. Circ. 16, 1927.

Horner, J. T., The Detroit Milk Market. Mich Agr. Exp. Sta. Bul. 170, 1928.

Clement, C. E., and Grant, F. M., Equipment for City Milk Plants. U. S. Dept. Agr. Circ. 99, 1929.

Lininger, F. L., The Relation of the Basic Surplus Marketing Plan to Milk Production in the Philadelphia Milk Shed. Penn. State Agr. Exp. Sta. Bul. 231, 1928.

CHAPTER XIII

PRODUCERS' COOPERATIVE MILK-MARKETING ORGANIZATIONS

According to Metzger (1) producers' marketing associations marketed about two-fifths of the milk sold in the United States during 1928. This milk had a value of over $325,000,000.

Producers' cooperative milk-marketing associations may be classified as:

1. Bargaining associations.
2. Wholesaling associations.
3. Distributing associations.

1. Bargaining Associations.—The typical bargaining association operates no facilities for the physical handling of milk either in the country or in the city. The chief function of this type of association is to represent the producer in all price negotiations for the sale of his milk. The producers are represented by a sales committee at all meetings where prices are negotiated. The association does not receive or physically handle any milk and usually does not pay the producer for his milk, the check being mailed directly by the milk dealer or distributor. This type of association can be started with a relatively small amount of capital. It has not the power, however, which is possessed by the wholesaling type. The dealer has a direct contact with the individual members and may be able to procure his supply direct from them in case of difficulties with the association.

The associations supplying Boston and other New England cities, Philadelphia, Pittsburgh, Baltimore, and Washington are of the bargaining type.

2. Wholesaling Associations.—These associations have facilities for the physical handling of the milk and also perform all the functions of a bargaining association. They own country receiving stations and also manufacturing plants where the surplus can be held and manufactured into milk products. A few of them have plants in the city from which milk is dispensed to dealers, in bulk and in a few instances in bottles. All receipts for milk from the dealers pass through the association so that the association has a constant contact with its members. In case of difficulties between the dealers and the association, it is possible for

the association to withhold the milk if it so desires, as it has the facilities for manufacturing the milk into milk products. It may thus have a greater bargaining power than the strictly bargaining association. As the distributors usually do not own or operate the country plants, they are more dependent on the association for their supplies.

A considerable amount of capital is necessary for the operation of this type of association because of the large investments in plants that are necessary.

Associations of this type supply milk to New York City, St. Paul, Minneapolis, and Los Angeles.

3. Distributing Associations.—Under this class are associations which actually distribute market milk at retail to the ultimate consumer and often also at wholesale to stores, restaurants, etc., in competition with the milk dealers or distributors.

This type of association may be divided into two classes: (*a*) The local or small association. These associations handle all the milk from the time it is produced until it is delivered to the consumer (either retail or wholesale). (*b*) The large association. With this class the distributing business is sometimes a minor part of its operations, its main functions often being those of the bargaining and wholesaling associations.

(*a*) *The Local or Small Association.*—The members of these organizations usually consist of a number of producers who have been retailing their own milk, or of producers and small dealers. By combining, both in the operation of a plant and in delivery to the consumer, considerable duplication of effort can often be eliminated and the milk delivered at less cost. Usually a central plant is established in the city, and the farmers bring their milk to the plant.

In 1921 a questionnaire was sent to all the leading milk producers' associations in the United States, and the following pages are based on the information received from those associations that operated distributing plants.

REASONS FOR ORGANIZING AND ESTABLISHING A CENTRAL DISTRIBUTING PLANT

There have been various reasons for producers organizing and establishing distributing plants. As a general rule, the local economic situation made it imperative that some change be made. The following reasons for organizing and establishing plants were given in replies from twenty-eight milk producers' cooperative associations who operate central plants:

Reasons Given.	Number of Associations.
To establish a permanent all-the-year market for the milk of the producers	9
To get better prices for the milk	9
To make it possible to comply with city pasteurization ordinance	3
To eliminate duplication	3
To effect more economical distribution	3
To establish a market for the local producers	2
To be able to give better service to the city	2
To handle the surplus	2
To give the producers more time for their farm work	1

Some of the associations gave two or more reasons, but the most common reasons given were to establish a permanent all-the-year market and to get better returns from their milk. These prevailing reasons were really the result of necessity in many cases; i.e., the producers were driven to do something on account of the uncertain market and the low prices received. Other important reasons are to eliminate duplication and to handle the surplus milk. Many of the associations consist in part of producers who have been retailing their milk, and in those cases the organization of the association and the establishment of a plant naturally eliminated considerable duplication and permitted the producers to spend their entire time with milk production. In one city, the establishment of such a plant reduced the number of delivery outfits required to supply a certain number of people from 15 to 5.

MEMBERSHIP

Of a total of twenty-three associations, the number of members varied from 14 to 650, with an average of 139, and the membership consisted of producers, producer-dealers and others, usually business people, in the town where the milk was to be distributed. Thirteen associations had some members who were not producers, and of the total 3206 members in twenty-three associations, 623 were not producers. In four of the associations 50 per cent or more were former retailers, and the membership of fourteen of the twenty-three associations consisted, in part, of former retailers. Of the 2583 producers in twenty-three associations, 453 were former retailers. One association had a considerable number of consumers in its membership, while another association consisted of 20 producers and 10 employees of the plant.

The intention of all associations is to have the membership consist primarily of milk-producers, and almost invariably the control of the

business is wholly in the hands of the producers. Where both preferred and common stock are issued, the preferred stock is usually sold to men who are not milk-producers and gives the holder no voting privilege. This preferred stock is often retired after a certain period of years, so that in time all the stock is held by milk-producers. Similarly, where certificates of indebtedness are originally issued to men who are not producers, they give the holder no voting privilege, and a certain number are usually retired each year and new certificates issued to milk-producers only, so that they are eventually all in the hands of milk-producers.

METHODS OF FINANCING

Various methods are used to raise the capital necessary to finance the organizations and establish and equip the plants. Formerly, the most common method was to issue capital stock. The common stock with the voting privilege is issued to milk-producers and, where additional capital is desired, preferred stock with no voting privilege is usually sold to business men. The preferred stock usually has a definite dividend allowance, while the common stock is usually limited to a certain maximum percentage for dividend payments. The organization with no capital stock has been more common in recent years. Usually, a membership fee is charged and certificates of indebtedness are issued. These certificates carry a definite percentage of interest and are sometimes sold to outsiders as well as to the producers. All memberships are, of course, held by milk-producers and each member has one vote. Often a form of contract is signed by the producer in which he agrees to send his milk to the association for a certain period of years, and he gives the association the privilege to deduct, from his milk check, amounts required each month to take care of the operation of the plant and also a certain amount to take care of depreciation and to supply a fund to retire the certificates of indebtedness. The plan is usually to retire a certain number of the certificates each year and to gradually get them all in the hands of the producers in proportion to the quantity of milk they are shipping to the association. While it is desirable for the entire membership to consist of milk-producers, it is sometimes necessary to raise more money than the producers can put up; outside capital must therefore be obtained and this is one of the ways used to get it.

Of a total of twenty-eight associations, eighteen issued capital stock and six issued certificates of indebtedness only, while four associations issued both capital stock and certificates of indebtedness. The average authorized capitalization of twenty-one associations was $65,857.14, varying from $5000 to $225,000.

Basis of Subscription.—Various bases of subscription to capital stock and certificates of indebtedness were used, and the following are among those reported:

$5.00 per quart of milk shipped daily.
$50.00 per 50 pounds of milk shipped daily.
$4.00 per gallon of milk shipped daily.
$50.00 per cwt. of milk shipped daily, etc.
$5.00 per cow owned.
$10.00 per cow owned, etc.
Not less than $250.00.

The limit in the amount of investment one member could hold in the association varied in fifteen associations from $100 to $10,000. In eleven of the associations there was no limit to the amount one member could hold.

METHODS OF VOTING

At the stockholders' or members' meetings, one man is allowed only one vote, with no proxies, in twenty-three of the associations, while at five of the associations the stockholders vote according to the shares of stock held.

TABLE 36

NUMBER OF ROUTES AND NUMBER OF EMPLOYEES IN 21 PRODUCERS' COOPERATIVE MILK PLANTS

Size of Plant. (Number of Gallons Handled Daily.)	No. of Plants.	Average Number Gallons Handled per Plant.	Number of Routes.				Number of Men Inside Plant.		Average Number Route Foremen per Plant.	Average Number Office Clerks per Plant.
			Wholesale.		Retail.					
			Average per Plant.	Per 100 Gallons Handled.	Average per Plant.	Per 100 Gallons Handled.	Average per Plant.	Per 100 Gallons.		
500 gals. or less...	9	380.5	0.5	0.12	3.5	0.88	3.0	0.76	0.0	1.0
501 to 1000 gals..	7	793	1.1	0.14	4.0	0.50	5.6	0.70	0.5	2.1
1001 to 2000 gals	5	1760	2.8	0.21	2.6	0.20	10.4	0.60	0.5	3.4

OPERATING METHODS

In Table 36 are shown the number of plant employees, delivery routes, office clerks, etc., at cooperative milk plants of various sizes. In this respect cooperative plants do not differ from ordinary privately owned plants.

INVESTMENTS IN PLANT AND EQUIPMENT

As is the case with privately owned plants, there is a great variation in investments at producers' milk plants. In Table 37 are shown the

investments at various plants arranged according to quantity of milk handled daily.

FIG. 39.—Delivery outfits of a producers' cooperative distributing plant.

METHODS OF HANDLING SURPLUS

All the plants have a surplus of milk to handle at certain seasons of the year. This is also true in the case of practically all milk dealers, except in cases where arrangements are made for the producers to handle it. The following is a tabulation of the replies from twenty-eight associations as to how they disposed of the surplus:

Commodity Sold.	Number of Associations.
Butter and cottage cheese	23
Sweet cream	9
Buttermilk	5
Ice-cream	3
Condensed skim	2
Skim milk to producers	2
Milk powder	1
Ice-cream mix	1

The most economical method of disposing of the surplus depends, of course, on market conditions and prices and the cost of manufacture. The market for cottage cheese is limited and irregular in most places; but where there is a good market for it the manufacture of butter and cottage cheese is a very satisfactory method of handling the surplus.

The sale of sweet cream is very profitable where there is a good market for it and the price is favorable.

TABLE 37

INVESTMENTS IN PLANT AND EQUIPMENT AT 27 PRODUCERS' COOPERATIVE MILK-DISTRIBUTING PLANTS ARRANGED ACCORDING TO QUANTITY HANDLED

Size of Plant. (Number of Gallons Handled Daily.)	Number of Plants.	Average Number Gallons Handled Daily.	Investment in Plant.		Investment in Plant Equipment.		Investment in Delivery Equipment.		Total Investment.	
			Average per Plant.	Per 100 Gallons.	Average per Plant.	Per 100 Gallons.	Average per Plant.	Per 100 Gallons.	Average per Plant.	Per 100 Gallons.
500 gals. or less.....	9	413.9	(1) $10,000.00	(1) $2,597.40	$11,811.21	$2,873.00	$2,893.75	(2) $ 666.19	(1), (2) $21,433.44	(1), (2) $5,170.85
501 to 1000 gals...	7	793	(3) 18,977.87	(3) 2,277.34	25,208.68	3,179.48	11,185.79	1,407.21	(3) 49,985.43	(3) 6,304.47
1001 to 2000 gals...	5	1760	(3) 22,515.76	(3) 1,169.65	(4) 20,933.77	(4) 1,189.42	7,146.06	(4) 433.09	(3), (4) 49,482.13	(3), (4) 2,811.48
2001 to 8000 gals...	6	4199.66	94,750.25	1,914.38	60,960.15	1,234.01	19,475.25	521.19	(5) 155,136.34	(5) 3,697.72
	27	1602.7	$36,339.02	$1,945.79	$26,624.28	$1,697.77	$8,556.39	$702.29	$63,749.18	$3,954.47

The average investment in plant buildings at eighty-four privately owned plants, ranging in size from 100 gallons or less to over 10,000 gallons daily was $24,183, and the averge investment per 100 gallons handled daily was $1327, based on 1916 prices. (6)

The average investment in plant equipment at one hundred and twenty-five privately owned plants, ranging in size from 100 gallons or less to over 10,000 gallons daily, was $24,475, and the average per 100 gallons handled daily was $1159, based on 1916 prices. (7)

(1) Only five plants in this group had buildings of their own.
(2) One plant in this group had no delivery system and was not of the strictly distributing type.
(3) One plant in this group rented a building.
(4) The business of one plant in this group was almost entirely wholesale.
(5) Two plants in this group had no delivery system and were not of the strictly distributing type.
(6) U. S. Department of Agriculture Bulletin No. 849.
(7) U. S. Department of Agriculture Bulletin No. 890.

SYSTEMS OF PAYING FOR MILK

Ten associations paid a flat price for milk, based on market conditions, while at fifteen of the associations the price paid was based entirely on the profits made by the association; i.e., the price was dependent upon the operating costs for the current month. At one association a flat price based on the market was paid for milk received from non-members, while the members of the association received for their milk a price based on operating costs. This price was usually considerably more than the price paid to non-members.

The logical method of payment for a cooperative association of this type is to have the price based on the operating costs for the current month. With this method, the producer gets what is left after expenses and reserves are deducted. Some associations have encountered considerable difficulties in the first few months, because the plant was started with the idea of paying a flat price for milk and under conditions where there was considerable competion in buying milk. Usually, cooperative associations find the first few months of operation very trying and costly until the plant is running smoothly and the business well established. During the first few weeks of operation, they often receive a large quantity of milk, which cannot be sold as market milk, but must be manufactured into by-products and disposed of at a lower price. If the producers are paid market-milk price for their milk under these conditions, the plant will be operating at a loss, and the proposition will be very discouraging. The organization also loses its cooperative feature to a large extent where milk is paid for on a flatrate basis.

Basis of Payment.—Twenty-one of the associations reported that the milk was paid for by weight, while at six of the plants the measure or gallon was used as the basis of payment. Butter-fat content was taken into consideration at nineteen of the plants. A large proportion of the associations paid on the weight and butter-fat basis. This is recognized as the most accurate and equitable method of paying for milk.

SINKING OR RESERVE FUND

Nearly all the associations had some method of setting aside a sum each month to take care of depreciation, etc., only four out of twenty-eight associations reporting that no such fund was set aside. Figures from sixteen associations showed that they were putting aside, on the average, $622.20 per annum for each 100 gallons of milk handled daily. The various associations varied from $365 to $1032.12 per annum per 100 gallons handled daily. While the most common system was to set aside a definite flat sum each month, some of the associations based the amount to be set aside on such factors as the following:

(1) Depreciation:
3 per cent on plant investment
20 per cent on plant equipment investment
33 per cent on delivery equipment investment
10 per cent on plant equipment
25 per cent on automobiles
10 per cent on horse, wagons and harness

(2) Milk handled or business done:
$\frac{1}{2}$ cent per gallon handled
1 cent per gallon handled
1 cent per cwt. handled
6 per cent of gross sales
$\frac{1}{4}$ cent for each quart of retail sales

Too much emphasis cannot be put on the importance of setting aside a sum each month to take care of depreciation, buying new equipment, etc. Some associations have encountered great difficulties because they had no fund to fall back on; and cases have been known where all the available funds have been paid out for new equipment, etc., so that the producers had to wait a month or more for their milk checks. If such associations had paid a little less to the producers each month, and at the same time set aside a definite sum into a reserve fund each month, there would not have been this shortage of funds.

OTHER ACTIVITIES CARRIED ON BY MILK PRODUCERS' ASSOCIATIONS

Eleven out of twenty-eight of the associations carried on other activities besides the handling of milk. The following is a tabulation of those activities:

Buy feed cooperatively	5	associations
" fertilizer cooperatively	4	"
" coal cooperatively	1	"
" grass seed cooperatively	1	"
" twine cooperatively	1	"
" groceries and meat cooperatively	1	"
" dairy supplies cooperatively	1	"
Handle eggs cooperatively	1	"

SOME ESSENTIALS TO THE SUCCESS OF SMALL MILK PRODUCERS' COOPERATIVE PLANTS

It should be remembered that producers' milk plants of the type described are not always successful and that it is not always advisable to establish such plants, many factors being essential to their success.

In the first place, there must be an economic need for such a plant; i.e., the present system of marketing milk must be unsatisfactory and there must be general dissatisfaction among the producers as to prices and marketing conditions. If the producers are satisfied with present conditions, there is no necessity for such a plant. The initiative should come from the producers themselves and not from some outside promotor, or agitator.

It is also desirable that all the capital be raised by the producers, if possible, and that all the members be *bona fide* milk producers. It is sometimes necessary to get outside capital, but when this is done it is desirable that there be no voting privilege except for the producer-members and that each member have one vote only, regardless of the shares of stock held. Proper organization, proper financing and sufficient available capital are, of course, fundamental necessities.

Management.—Efficient management is of prime importance. The operation of a modern milk business is a complex and intricate proposition, and none but experienced men should undertake it. A capable board of directors must, of course, be selected, but it must not be considered that they are to run the plant. Instead, a technically trained and experienced man should be hired to take charge of the business. This man should be engaged as soon as possible after it is decided to establish a central plant, so that he can take charge of the construction and equipping of the plant as well as other matters connected with getting started, the details of which can be handled much better by him than by the directors. Some associations have tried to economize by hiring a second-class man at a little less salary, or a member of the association or one of his sons, as manager. This practice usually leads to disaster. The management of a milk plant is a specialized undertaking, and only a trained man, with experience, should be selected. If such a man is given the opportunity, the results will soon justify the added expense. As the success of the undertaking depends primarily on the management, no expense should be spared in getting a high-class man.

Spirit of Cooperation Necessary.—Finally, there must be a spirit of cooperation; unless the members cooperate under all conditions, success is doubtful. They must be willing, at times, to sacrifice their own inter-

ests, if necessary, for the good of the whole organization. At certain times, especially while the business is getting started, they may have to take less for their milk than they could get elsewhere, and unless they are willing to take losses at such times and stay with the association, success will be doubtful. There usually seems to be a better spirit of cooperation among small groups of men who know each other personally, and it often happens that the members of small associations cooperate better than do those of large ones.

Survey Should be Made.—It is important that a careful survey be made before it is attempted to establish a cooperative central milk plant, and the following are some of the points that should be considered:

(1) Are the producers now satisfied with the prices received and the general conditions under which they market their milk?

(2) Can milk be delivered to the consumer from a producers' central plant more economically than it is now being delivered?

(3) Is the consumer able at all times to get an ample supply of milk of good quality, and is the existing distributing system giving satisfaction?

(4) Will the producers be able to spend more time with their farm work if a central distributing plant is established?

(5) Will the members be loyal to the association and manifest a spirit of cooperation?

(6) Can sufficient capital be raised to finance the proposition?

(7) Can collecting routes be established to bring the milk from the farms to the plant economically, and at what distances from the city and from each other are the farms located?

(8) Can a capable manager be secured at an early date to take charge of the business?

(9) Of what will competition consist, and will the producers be able to compete successfully with dealers already established?

(10) Can a sufficient supply of milk be secured to assure a regular supply, and what proportion of the total supply can be counted on?

RESULTS OBTAINED BY CERTAIN PRODUCERS' PLANTS

The following are some of the results that have been obtained at certain successful producers' cooperative milk plants started under favorable conditions, according to reports that have been received:

(1) Satisfaction among the producers and no disputes between producers and dealers as to prices, etc.

(2) Elimination of wasteful competition and unnecessary duplication of delivery routes, resulting in large loads and a reduction of delivery costs.

(3) More of producers' time left free for farm work.

(4) A uniform and better product available at all times to the consumer in sufficient quantities.

(5) Better prices to producers without increase in the price to the consumer. (This will not necessarily follow, however, in all cases, and depends entirely on the local conditions and on the management.)

(6) Increased production by the producers.

(7) Economical disposal of surplus milk.

Many of the plants which have been started have not succeeded, the cause of failure, in many cases, being faulty management. Not only must a manager, to be successful, have the qualifications necessary for efficiently operating a milk business, but he must also be able to keep the farmers together and satisfied under trying conditions. A good manager will make every possible effort to keep the organization together. The farmers, on their part, should not expect a cooperative milk-distributing plant to be put on a paying basis immediately, at the start.

Other causes of failure by the manager have been poor judgment in dealing with competitors and in making prices. Although the making of prices may be left to the Board of Directors, the advice of the manager is essential. He must know what his cost of operating the business will be, to be able to decide at what price the milk can be sold without loss to the plant.

Where there are other milk dealers in the town, competition will probably be of considerable importance, and it cannot be expected that the business will grow very fast at first. However, after the plant is firmly established, many of the other dairymen often join the association and in this way producers' organizations often get a good portion of the business.

Table 38 gives information relative to several producers' cooperative milk-marketing organizations of the small local distributing type. This information was collected several years ago, and information as to the present status of these associations has not been obtained.

(*b*) *The Large Association of the Distributing Type.*—Most of the producers' organizations that have organized for the distribution of milk to the consumer have been of the small or local type previously described. There are, however, a few distributing associations that operate on a large scale. The Cooperative Pure Milk Association, which operates in Cincinnati, Ohio, is probably the largest association of this type whose chief function is distribution to the consumer. It had sales for 1928 of over $2,000,000. The Ohio Farmers' Milk Association operates in Cleveland, Ohio. Both of these associations were formerly

TABLE 38

A List of Some of the Producers' Cooperative Associations which Distribute Milk, with Some of the Salient Features as to Organization, etc.*

Name and Address of Association or Company.	Amount of Capitalization.	Year of Organization.	Ownership of Stock.	Estimated Value Physical Assets in 1919.	Average Daily Quantities. Gallons.	Number of Sales Routes.
Dubois Dairymen's Cooperative Ass'n, DuBois, Pa.	$5,000	1917	Producers and dealers	$ 10,000	500	5
Cooperative Dairy Co., Sedalia, Mo.	25,000	1919	Producers and others	20,000	300	3
Streator Dairy Co., Streator, Ill.	10,000	1916	Producers and dealers	16,000	200	3
New Tri-State Sanitary Milk Co., Cumberland, Md.	45,000	1918	Producers and others	40,000	1000	7
Dairymen's Milk Co., Kalamazoo, Mich.	2,000	1906	Producers	20,000	750	10
Grand Rapids Dairy Co., Grand Rapids, Mich.	200,000	1916	Producers and others	100,000	3000	34
Westfield Milk Exchange, Westfield, Mass.	30,000	1920	Producers and others	25,000	1000	3
Easthampton Milk Exch., Easthampton, Mass.	25,000	1919	Producers and others	25,000	1000	6
Producers' Dairy Co., Brockton, Mass.	150,000	1919	Producers and others	100,000	2000	24
Newport Cooperative Dairy Co., Newport, R. I.	100,000	1918	Producers and others	65,000	3000	20
Farmers' Cooperative Dairy Co., Bridgeport, Conn.	100,000	1918	Producers and others	80,000	4000	10
Milk Producers' Union, Indianapolis, Ind.	18,000	1917	Producers	20,000	1500	20
Pittsfield Milk Exch., Pittsfield, Mass.	150,000	1920	Producers and others	32,000	2500	
Erie County Milk Ass'n, Erie, Pa.	30,000	1899	Producers and dealers	150,000	3300	29
Midwest Milk Producers' Cooperative Ass'n., Omaha, Nebr.	50,000	1919	Producers	40,000	4000	

* Adapted from Circular No. I, "Marketing Dairy Products," Bureau of Markets, U. S. Dept. of Agriculture.

of the bargaining type only. They have gone into the distributing field comparatively recently and are competing directly with the established milk distributors with whom they formerly dealt as bargaining organizations.

The Dairymen's League Cooperative Association of New York, though functioning primarily as a bargaining and as a wholesaling association, has gone into the distributing field on a comparatively small scale. This association has purchased the handling facilities and businesses of a few former milk distributors in New York and surrounding cities and competes with the established distributors in the distribution of milk. Although the business done by the association in this field is of considerable volume, it is very small when compared with the total milk this association handles as a purely wholesaling and bargaining association, and its distributing business is of comparatively minor importance.

REFERENCES

Clement, C. E., Milk Distribution by Producers' Cooperative Associations, Report of International Association of Dairy and Milk Inspectors, 1921.

Jesness, Barber, Swarthout and Clement, Producers' Cooperative Milk Distributing Plants. U. S. Dept. Agri. Bul. 1095, 1922.

Circular No. 1, U. S. Bureau of Markets.

Erdman, H. E., The Marketing of Whole Milk, 1921.

King, Clyde L., The Price of Milk, 1920.

(1) Metzger, Hutzel, Cooperative Marketing of Fluid Milk. U. S. Dept. of Agr. Tech. Bul. 179, 1930.

CHAPTER XIV

THE TRANSPORTATION OF MILK

After the milk is produced on the farm, it must be collected or assembled in the country and transported to the city. Milk is transported from the producer's farm to the dealer in the city, either by direct shipment or through country receiving stations which are often built beside the railroad tracks. Where milk is sent by direct shipment, it may go by wagon, truck, or steam or electric railroad. When the milk is sent through country receiving stations, it is usually brought to the receiving station by wagon or truck, by the producers or by paid haulers, and shipped to the city by steam road. In some sections, however, where there are good concrete roads and the stations are located

Fig. 40.—Milk hauled by automobile.

comparatively near the city, the milk is trucked from the station to the city. In some cases, the man who has charge of the station also does the trucking, and he is often paid so much per hundred pounds handled.

Tank trucks, which consist of specially lined, insulated tanks mounted on automobile trucks, are now used extensively for transporting milk in bulk from country receiving stations to the city plant.

Where the milk is shipped by rail from the country station to the city the milk dealer or middleman makes all arrangements with the railroad company. He must have the train arrive at a definite time

each day and he must have the milk ready when the train arrives. Later in the day the train will make the return trip with the empty cans. Where this system of transportation is used the dealer will have milk arriving from different stations at different times. Such shipments are often by C L lots, but they may be L C L, as in the case of direct shipments, and the milk for various dealers may be received on the same car. In that case it must be reassembled at the city terminal.

Where milk is shipped by train, refrigerator cars are generally used and in most cases the freight charged by the railroad company for L C L shipments includes icing in summer and heat in winter when necessary, although in most C L shipments the shipper (milk dealer) will see that the milk is properly iced. For short distances the milk car may be attached to a regular passenger train and " pick up " milk from several stations on the way to the city, but for long distances the milk cars are made up into regular milk trains with fast express service to the city.

TRANSPORTATION OF MILK BY STEAM RAILROAD

It is claimed (18) that the first milk to be transported by railroad in the United States was a shipment made into Boston, Mass., over the old Boston and Worcester railroad in 1838 and that the first milk car was run soon after between Westboro and Boston. In 1843 (18) the " New England Farmer " stated that a single dealer brought to Boston over the Worcester railroad 200,000 gallons of milk a year. This was about 10 per cent of the city's entire supply at that time. Prior to 1870 all the milk consumed in Boston came from a distance of not more than 65 miles. (7) By 1890 the Boston and Maine was bringing milk from a distance of 150 miles and in 1910 a distance of 275 miles. At the present time milk is received in Boston from distances of over 350 miles and cream is often received from Middle West points about 1000 miles distant.

Prior to 1842 practically all milk consumed in New York City was brought in by wagon, and the first shipment was made by rail in 1842. (7) By 1910 milk was shipped into New York by rail from distances of over 300 miles, and at the present time shipments are made from nearly 400 miles distant. In May, 1930, there were shipped into New York City 30,290,710 gallons of milk over 10 railroads. (13)

Prior to 1870 Philadelphia was receiving its milk from an area within a radius of 50 miles of the city and the greater part of this was received by railroad. (7) In 1923, 55,273,056 gallons or 78.5 per cent of the total supply was received by railroad. (5)

According to Parker (1) the percentage of milk received by railroad in 1916 was as follows for various cities:[1]

New York	98	per	cent	St. Louis	75	per cent
Chicago	95	"	"	New Orleans	65	" "
Boston	90	"	"	Milwaukee	60	" "
Philadelphia	83	"	"	San Francisco	60	" "
Baltimore	75	"	"	Cleveland	55	" "
Cincinnati	75	"	"	Washington	50	" "

Detroit received 41.8 per cent by steam railroad (6) in 1915. For some of these cities the percentages received by steam railroad in 1923–1924 were as follows, based on data of the Bureau of Public Roads: (5)

Baltimore	55.0	per	cent
Philadelphia	78.5	"	"
Detroit	2.1	"	"
*Milwaukee	0.5	"	"

* 87.5 per cent by motor truck.

At the present time the percentages received by railroad are considerably less for many of these localities because of the increased use of motor trucks. Philadelphia, for example, now receives over 50 per cent of its milk supply by truck, and Chicago receives about 60 per cent by truck. Boston, however, still receives over 90 per cent of its supply by rail, and New York City receives approximately 97 per cent by rail.

The receipts of milk and cream in New York, Boston, and Philadelphia for June, 1930, are shown in Table 39.

TABLE 39

RECEIPTS OF MILK AND CREAM IN NEW YORK, BOSTON, AND PHILADELPHIA FOR JUNE, 1930. (14)

City.	Milk. 40-quart Units.				Cream. 40-quart Units.			
	By Rail.	By Truck.	Total.	Per Cent by Rail.	By Rail.	By Truck.	Total.	Per Cent by Rail.
New York	3,029,071* (13)	93,000* (13)	3,122,071* (13)	97.2	209,868	....	209,868	100
Boston	500,105	39,192	539,297	92.7	63,766	....	63,766	100
Philadelphia	273,823	343,213	617,036	44.4	40,578	871	41,449	97.9

* For May, 1930.

[1] From Parker's City Milk Supply, by permission of the McGraw-Hill Book Company.

The method of transporting Chicago's milk supply (16) in April, 1928, is indicated in Table 40.

TABLE 40

MANNER OF TRANSPORTING CHICAGO'S MILK SUPPLY, APRIL 1, 1928. (16)

Method.	Percentage of Total Supply.
Tank cars	55.5
Tank trucks	20.0
By truck (in cans)	17.0
Rail (in cans and in bottles)	7.5
	100.0

At the present time (1930), according to the records of the Chicago Health Department, the Chicago supply is transported as indicated in Table 41.

TABLE 41

MANNER OF TRANSPORTING CHICAGO'S MILK SUPPLY, AUGUST 1, 1930. (8)

Method.	Percentage of Total Supply.
Tank cars	38.5
Tank trucks	40.0
By truck (in cans)	21.3
By rail (in cans and in bottles)	0.2
	100.0

In November, 1927, a typical month, there were shipped into Boston, Mass., over 3 railroads and originating in 8 states and Canada, 15,673,808 quarts of milk and 1,702,092 quarts of cream.

Types of Cars Used.—The cars used for the transportation of milk vary in construction. Small shipments are made in ordinary baggage cars with no icing. For regular milk shipments, however, where large amounts are shipped for considerable distances, the refrigerator car is used almost exclusively. The sides, top, and usually the floors of these cars are insulated, and some of them have ice bunkers in the ends.

Where bunkers are not used the milk is kept cold in transit by throwing ice on top of the cans. Sometimes this is done also when cars are provided with bunkers.

The milk cars that were formerly used in New England were different from the ordinary milk car, and $8\frac{1}{2}$-quart cans were used almost entirely for shipping milk. These cars were 48 feet long inside measurement and $8\frac{1}{2}$ feet wide. In the center of the car was an office for the caretaker. This had dimensions of $8\frac{1}{2}$ feet by 9 feet; in it was a chair for the caretaker, a stove, and a desk which could be used for keeping records. The office had two windows on each side and at each end was a door leading to the two ends of the car which contained the milk. In each end of the car there were 4 closets, making 8 in all. These were $3\frac{1}{2}$ feet by 4 feet, with two or three shelves, thus accommodating 3 or 4 tiers of cans. Each tier held thirty $8\frac{1}{2}$-quart cans, so that each closet had a capacity of 90 or 120 cans and the whole car had a closet capacity of 720 or 840 $8\frac{1}{2}$-quart cans. There were two doors opening to the space in each end of the car for receiving the cans, storing and breaking ice, and handling the cans. A considerable portion of the milk shipped in these cars would be "picked up" at way stations; the caretaker would receive it at the side doors and as soon as possible place it in the closets. He would then throw cracked ice over the cans. As soon as a closet was filled and the milk iced, the doors were closed and kept closed until arrival in Boston. Some cans of milk were placed on the floor space of the car after the closets were filled. A full carload was from 960 to 1000 cans.

This type of car has now practically gone out of use and most of the milk in New England is now transported in 10-gallon cans, as is done in other sections of the country.

The following is a brief description of one type of refrigerator car now used for transporting milk in New England:

Inside dimensions: Length, 40 feet, $5\frac{3}{8}$ inches
Width, 8 feet, 4 inches
Height, 7 feet, 7 inches

Sides, top, and floor insulated with 2 inches cork board and 2 inches hair felt.
End bunkers, 3 feet by 6 feet by 8 feet, with a total ice capacity of 307 cubic feet. These bunkers are filled from the roof and special ventilators are provided for air circulation to insure uniform melting of the ice.
The temperature in the car is maintained at about 40° F.

The capacity of this car is 1344 $8\frac{1}{2}$-quart cans or 231 40-quart cans; if the 40-quart cans are decked above the floor tier more can be carried. The weight-carrying capacity is 69,000 pounds. One railroad company

has 261 cars of this type. The longest haul made is 284 miles; the shortest 116 miles. This same railroad company also uses in its milk service to Boston and other New England cities 83 so-called passenger milk cars. These are constructed similar to the other type except there are no ice bunkers and the milk is kept cold by throwing ice over the cans. These cars have a floor capacity of 252 10-gallon cans; if the cans are decked, more can be carried. They have a capacity of 1600 $8\frac{1}{2}$-quart cans, but this type of can is now little used for shipping milk to Boston. The inside dimension of this car are 50 feet, $4\frac{5}{8}$ inches long; 8 feet, $11\frac{1}{2}$ inches wide; and 7 feet high. The longest haul made by this type of car by this railroad company is 391 miles and the shortest haul is 67 miles.

One railroad company transporting milk into New York City has 381 milk cars, of which the following is a brief description of the latest type:

Length (inside), 49 feet, $2\frac{1}{4}$ inches
Width, 9 feet, $\frac{3}{8}$ inch

Insulation hair felt, quilt and canvas—top and sides.
Refrigeration by ice placed on top of the cans, no bunkers being provided.
Capacity, 70,000 pounds.
Will hold 383 40-quart cans on floor and 620 when they are double decked.
The longest haul is 435 miles and the shortest 38 miles.

Tank cars used in transporting milk are described elsewhere.

At stations where large quantities of milk—enough to fill a car—are shipped, cars are set off the day before; they are filled by the employees of the country station during the day and "picked up" when the train comes along, usually in the morning. In some cases a car will be set off at a plant which does not supply a full carload, and enough to fill it will be trucked from another plant. In other cases the milk train will "pick up" milk along the route, the railroad employees loading the milk into the car, sometimes with the help of producers or station employees.

According to Erdman (4) 25 per cent of the New York milk supply in 1916 originated at points where entire car lots were shipped. He also states that in 1916 twenty-one trains composed of from 8 to 25 cars, each running from 49 to 295 miles without a stop except for orders, etc., were serving New York City.

In different sections of the country milk is on the road from a few hours up to about 20 hours, depending on the distance and the service. Where this milk goes through a country plant it may be as much as 36 to 48 hours old when it reaches the city. Efficient refrigerating in transit is therefore a prime essential in milk transportation.

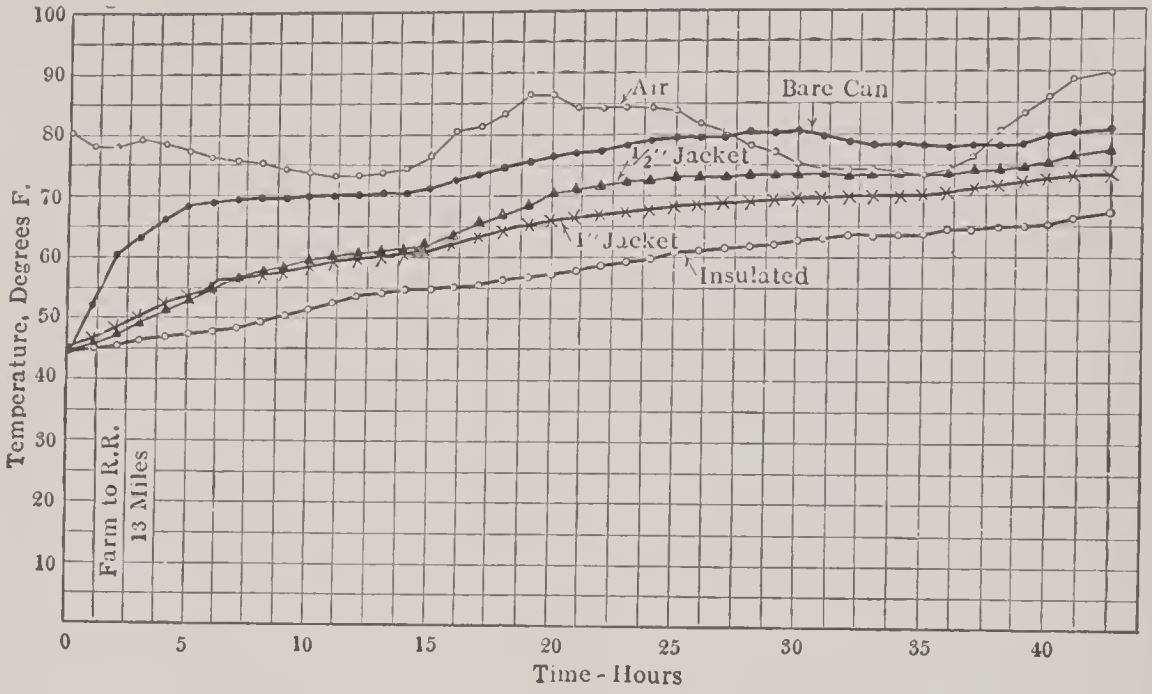


FIG. 41.—Relative efficiency of 4 types of cans in shipment of milk from Washington, D. C., to New Orleans, La. Milk cooled to 44° F. and hauled 13 miles in open truck to station. (11)

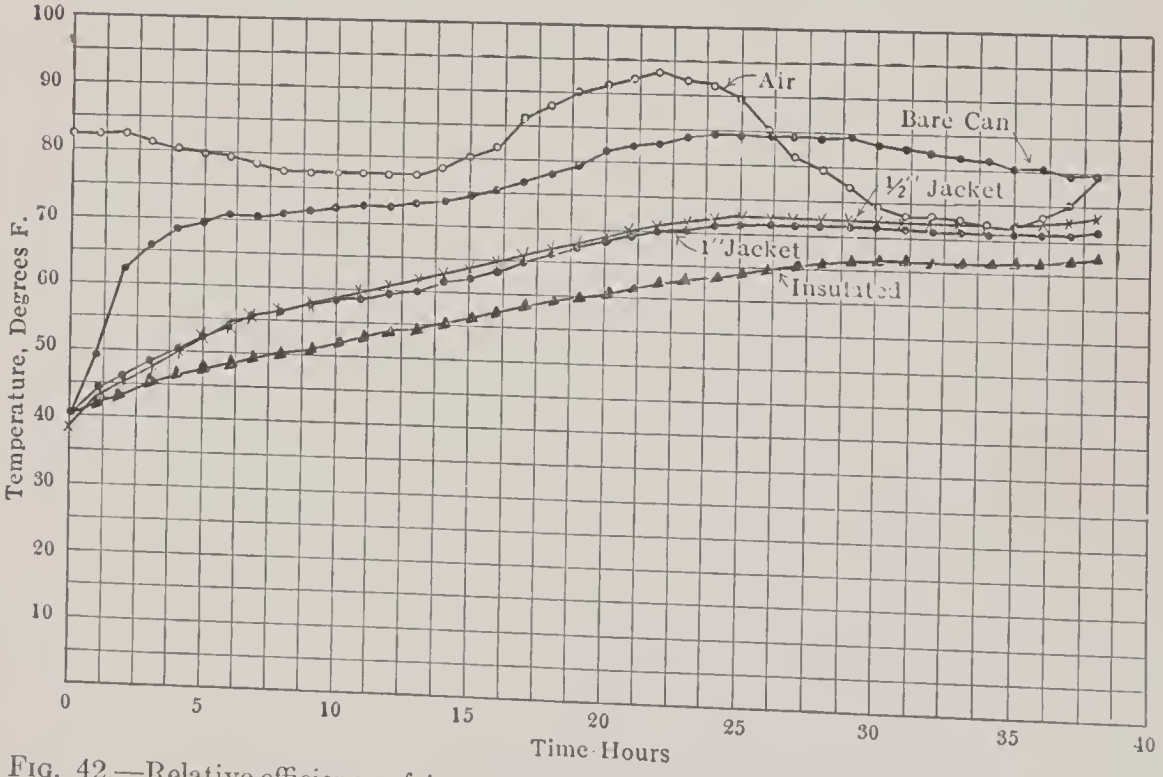


FIG. 42.—Relative efficiency of 4 types of cans in shipment of milk from New Orleans, La., to Washington, D. C. Milk cooled to 40° F. and loaded directly at station. (11)

TRANSPORTATION OF MILK AT LOW TEMPERATURES

To determine the relative efficiency of ordinary milk cans compared with jacketed and insulated cans in keeping milk cold during long shipments, some interesting tests were made by Gamble and Bowen.(11) Three experiments were tried: (*a*) a shipment of milk from Washington to New Orleans, (*b*) a shipment of milk from New Orleans to Washington, and (*c*) a shipment from Chicago to Washington. The results of these tests are shown in Figs. 41, 42 and 43.

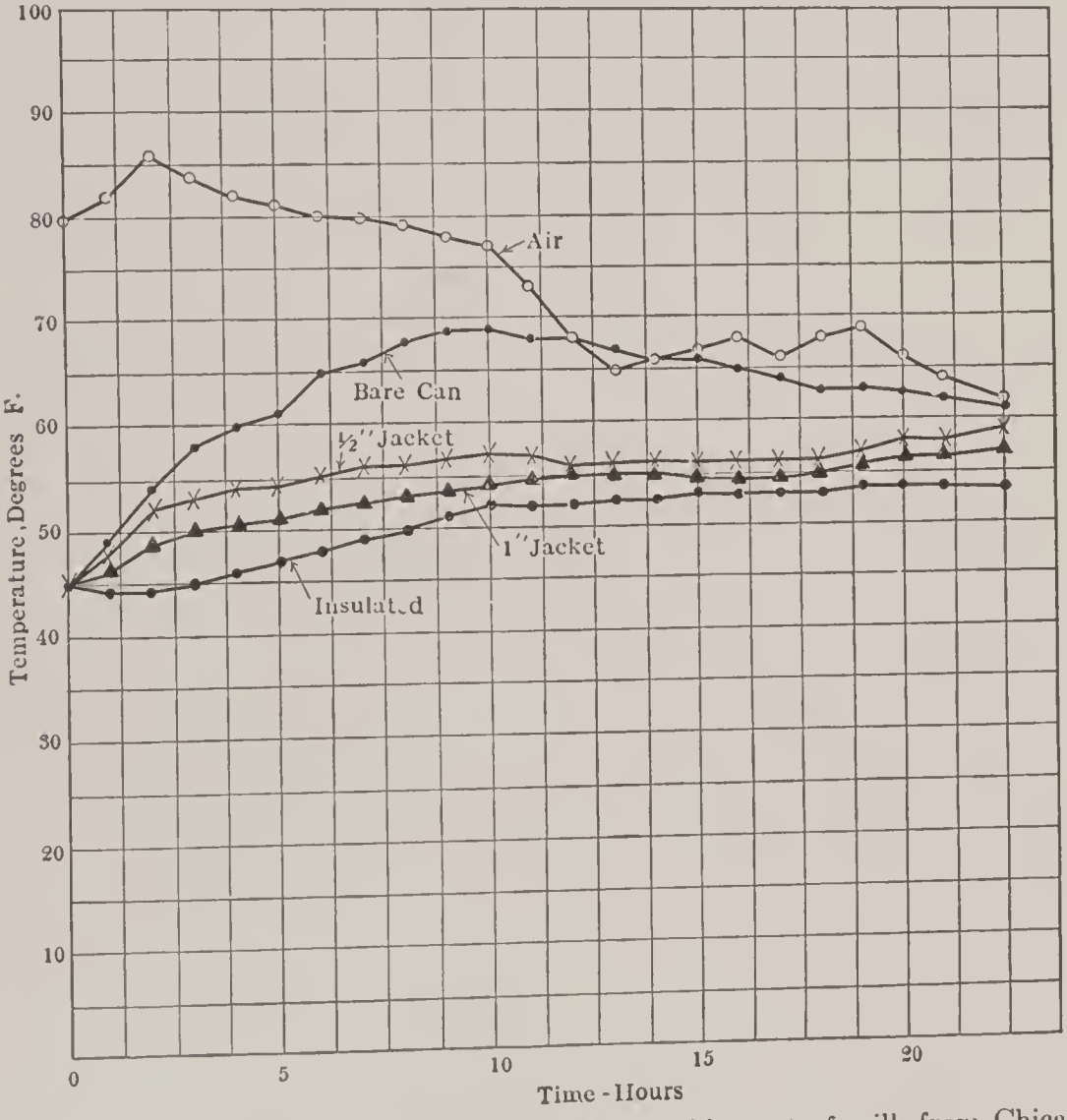


Fig. 43.—Relative efficiency of 4 types of cans in shipment of milk from Chicago, Ill., to Washington, D. C. (11)

LOSSES OF MILK IN TRANSPORTATION

A study of the losses of milk during transportation to Baltimore, Md., was made by one of the authors in August, 1920. A total of 346

shipments, consisting of 1102 cans of milk, were followed on the entire route, and the results are shown in the following table:

TABLE 42

Losses of Milk during Transportation

	Gallons.	Per Cent.
Difference between producer's manifest and amount actually shipped	76.54	1.21
Total loss between amount actually shipped and amount received at plant	43.14	0.69
Difference between amount credited at weigh can at city plant and amount actually shipped	159.74	2.56
Difference between amount credited at weigh can and amount manifested by producer	236.28	3.79

It is thus seen that not only did the producer claim, on his manifest, greater quantity than he actually shipped, but considerable milk was lost in the transit of the milk from the country to the city. Many of the cans used were old and battered, and in many cases the lids fitted loosely or actually leaked.

FREIGHT RATES AND SERVICE

Previous to about 1916 there was considerable blanketing of milk freight charges; i.e., for distances over a certain number of miles the rate was the same. Now, however, practically all milk rates are constructed on the distance principle. The rates will also vary according to the service rendered.

In 1905 the rates to New York City were as follows:

Distance.	Cents per 40-quart Can.
Up to 40 miles	23
40 to 100 miles	26
100 to 200 miles	29
200 miles and over	32

At the present time New York rate distances are divided into 40 zones of 10 miles each, and the rate varies per 40-quart can for L C L shipments from 23.5 cents in the 10-mile zone to 59.5 cents in the 391 to 400-mile zone.

As a general rule all cars which receive portions of their load at different stations take a L C L rate to destination. The Maine Central, (9) however, publishes a tariff for concentrated shipments which amounts to L C L rates to concentration points and C L rates from those points to destination. On other lines in New England all cars "picking up" milk at more than one station take a L C L rate even though moved through one or more junction points and over more than one railroad. In the report of the Interstate Commerce Commission in the New England Milk Case (10) (1916) a witness for the railroads summarized the special features connected with the transportation of milk in New England, besides the return of the empty cans, as follows:

"(1) Expedited service in passenger trains and preferred attention in fast freight trains.
"(2) Special equipment costing more than ordinary freight cars, as well as being more expensive to maintain.
"(3) Special handling in setting cars at plants in the Boston terminal
"(4) Transportation without charge of ice for refrigeration.
"(5) Free transportation of caretakers.
"(6) Expensive pick up and delivery service at various points."

Previous to this time rates on cream in New England were the same as the rates on milk, and it was urged by the dealers that there should be no difference. They said that both commodities move in the same kind of containers, in the same cars, and in the same trains, and are alike susceptible to deterioration in transit in the event of improper handling. In the report of this case, however, the Commission said that it had been shown that loss and damage claims had been negligible for each, and that cream was valued at about $17.10 per can whereas 4 per cent milk was valued at $2.46. They said that, although milk and cream were analogous commodities, they were distinct in character. The volume of the movement of cream was very much less than that on milk. Cream may be classed among higher grade commodities of greater value and can fairly bear higher rates than milk, and higher rates were charged by railroads transporting to New York City. In their decision the Commission ruled that the rates on cream in L C L shipments should not exceed by more than 25 per cent the rates which were prescribed for milk.

As a rule, freight rates now depend on the distance the milk is transported. All shipments within two or more states are subject to the regulations of the Interstate Commerce Commission. Tables below show the rates for milk and cream shipped to New York City and Boston, Mass.

TABLE 43

Rail Rates per 40-quart Can on Milk and Cream in the New York Territory*

(Rates for zones 1 to 12 are from schedules of rates prescribed by the New York Public Service Commission. Rates for zones 13 to 40 are from Interstate Commerce Commission Tariff Schedule No. 882.)

Zone.	Distance, Miles.	Less-than-carlot Shipments.		Car-lot Shipments.		Zone.	Distance, Miles.	Less-than-carlot Shipments.		Car-lot Shipments.	
		Milk. Cents.	Cream. Cents.	Milk. Cents.	Cream. Cents.			Milk. Cents.	Cream. Cents.	Milk. Cents.	Cream. Cents.
1	1– 10	23.5	29.5	20.5	26.0	21	201–210	45.5	57.0	40.0	50.0
2	11– 20	24.5	31.0	21.5	27.0	22	211–220	47.0	58.0	41.0	51.0
3	21– 30	26.5	33.0	23.0	29.0	23	221–230	47.5	59.0	41.5	51.5
4	31– 40	27.5	35.0	24.5	30.5	24	231–240	48.0	60.0	42.0	53.0
5	41– 50	29.5	36.5	26.0	31.0	25	241–250	48.5	61.0	42.5	53.5
6	51– 60	30.5	38.5	27.0	33.5	26	251–260	50.0	62.0	43.0	54.0
7	61– 70	32.0	39.5	27.5	35.0	27	261–270	50–5	63–0	44.0	55.0
8	71– 80	33.0	41.5	29.0	36.0	28	271–280	51.0	63.5	44.5	56.0
9	81– 90	34.0	42.5	30.0	37.0	29	281–290	51.5	65.0	45.0	56.5
10	91–100	35.5	44.0	30.5	38.5	30	291–300	53.0	65.5	46.0	57.5
11	101–110	36.0	45.0	32.0	39.5	31	301–310	53.5	66.5	47.0	58.0
12	111–120	37.0	47.0	32.5	41.0	32	311–320	54.0	68.0	47.5	59.0
13	121–130	38.5	48.0	33.5	42.0	33	321–330	54.5	68.5	48.0	60.0
14	131–140	39.5	49.0	34.0	43.0	34	331–340	56.0	69.5	48.5	60.5
15	141–150	40–0	50.5	35.5	44.0	35	341–350	56.5	70.0	49.0	62.0
16	151–160	41.5	51.5	36.0	45.0	36	351–360	57.0	71.0	50.0	62.5
17	161–170	42.0	53.0	36.5	46.0	37	361–370	57.5	72.0	50.5	63.0
18	171–180	43.0	53.5	38.0	47.0	38	371–380	58.0	72.5	51.0	63.5
19	181–190	44.0	54.5	38.5	48.0	39	381.390	59.0	74.0	51.5	64.0
20	191–200	45.0	56.0	39.0	48.5	40	391–400	59.5	74.5	52.0	65.0

* Shipped in milk or refrigerator cars on milk, passenger, or mixed passenger and freight trains, iced when necessary, to Melrose Junction, or 130th Street, New York.

Car-lot Freight Rates on Cream, Fast Passenger Service, from Mid-Western Points to Boston, 1926 † (3)

(Data obtained from freight department, Boston & Albany R.R.)

Shipping Point.	Rail Miles to Boston, Miles	Rate per 40-quart Can, Dollars.	Shipping Point.	Rail Miles to Boston, Miles.	Rate per 40-quart Can, Dollars.
Kansas, Hutchinson	1715	2.28½	Wisconsin:		
Iowa, Waterloo	1321	2.08½	Rice Lake	1415	2.16½
Minnesota:			Reedsburg	1228	1.98½
Watertown	1176	2.27½	Ripon	1215	1.97½
Minneapolis	1467	2.21½	Lodi	1195	1.95½
Northfield	1458	2.18½	Milwaukee	1131	1.85
St. Paul	1456	2.19½	Illinois, Chicago	1046	1.44½
			Michigan, Homer	861	1.27

† Via lines west of Chicago, Michigan Central, New York Central, and Boston & Albany R.R.'s.

TABLE 44

Schedule of Rail Rates * on Milk and Cream, New England Territory

(Source: Interstate Commerce Commission Tariff Schedule No. 4834.)

Zone.	Distance. Miles.	Less than Carload Shipments.				Car-lot Shipments.				Tank car per Quart.¶	
		Per 40-quart Can.†		Per 12-quart Case.‡		Per 40-quart Can.§		Per 12-quart Case.||			
		Milk. Cents.	Cream. Cents.	Milk. Cents.	Cream. Cents	Milk. Cents.	Cream. Cents.	Milk. Cents.	Cream. Cents.	Milk. Cents.	Cream. Cents.
1	1– 20	21.0	26.5	12.0	15.0	18.5	23.0	9.0	11.5	0.43	0.54
2	21– 40	25.0	31.5	15.0	19.0	22.0	27.5	11.5	14.5	.53	.66
3	41– 60	29.0	36.5	17.5	22.0	25.5	32.0	13.5	17.0	.62	.78
4	61– 80	32.5	40.5	19.0	23.5	28.5	35.5	15.0	19.0	.70	.88
5	81–100	35.5	44.5	19.0	23.5	31.0	39.0	15.0	19.0	.77	.96
6	101–120	37.0	47.0	19.0	23.5	32.5	41.0	15.0	19.0	.79	.99
7	121–140	39.5	49.0	20.5	26.0	34.0	43.0	17.0	20.5	.84	1.05
8	141–160	41.5	51.5	21.5	27.0	36.0	45.0	17.5	22.0	.88	1.10
9	161–180	43.0	54.0	23.0	29.0	38.0	47.0	18.5	23.5	.92	1.15
10	181–200	45.0	56.0	24.0	30.0	39.0	49.0	20.0	24.5	.96	1.20
11	201–220	47.0	58.0	25.0	31.0	41.0	51.0	20.5	26.0	1.01	1.26
12	221–240	48.0	60.0	26.0	32.5	42.0	53.0	21.5	27.0	1.02	1.28
13	241–260	50.0	62.0	27.0	33.5	43.0	54.0	22.0	27.5	1.07	1.34
14	261–280	51.0	63.5	27.5	35.0	45.0	56.0	23.0	29.0	1.09	1.36
15	281–300	53.0	66.0	29.0	36.0	46.0	57.5	24.0	29.5	1.13	1.41
16	301–320	54.0	68.0	29.5	37.0	47.5	59.5	24.5	30.5	1.16	1.45
17	321–340	56.0	69.5	30.5	38.0	48.5	60.5	25.0	32.0	1.20	1.50
18	341–360	57.0	71.0	31.0	39.0	50.0	62.5	26.5	32.5	1.22	1.53
19	361–380	58.0	72.5	32.5	40.0	51.0	63.5	27.0	33.5	1.24	1.55
20	381–400	59.5	74.5	33.0	41.0	52.0	65.0	27.5	34.0	1.27	1.59

* Effective June 10, 1927. Rates quoted are not applicable to shipments when service is performed wholly within the State of Massachusetts.

† Rates per can for less-than-carload shipments in milk or refrigerator cars (iced in summer and heated in winter), on milk, passenger, or mixed passenger and freight trains; also applicable to shipments in baggage cars (no icing) on passenger trains between points where milk or refrigerator cars (iced or heated) are provided.

‡ Rates for less-than-carload shipments, in bottles, or in milk or refrigerator cars (iced in summer and heated in winter) on milk, passenger, or mixed passenger and freight trains; also applicable to shipments in baggage cars (no icing) on passenger trains between points where milk or refrigerator cars (iced or heated) are provided.

§ Rate per can for carload shipments in milk or refrigerator cars, on milk, passenger, or mixed passenger and freight trains; ice furnished by shipper.

|| Rates for carload shipments in bottles, in milk or refrigerator cars on milk, passenger, or mixed passenger and freight trains, ice furnished by shipper.

¶ Rates per quart for carload shipments in tank cars, on milk, passenger, or mixed passenger and freight trains; the minimum to be the carrying capacity of tank, but not less than 8925 quarts; ice furnished by shipper.

HAULING MILK

Where milk is shipped to the city by steam road, it must be collected from the farmers and brought to the railroad shipping stations, in the case of direct shipments; and to the country plant where it is handled

FIG. 44.—Interior of milk car showing method of icing the milk.

through country receiving and cooling stations. Usually one producer will bring in the milk of several of his neighbors, besides his own; and in many cases, hired haulers, who make a business of hauling milk,

FIG. 45.—Receiving milk by railroad.

bring it in. In some cases, especially where the milk goes through a country plant, the dealers themselves have installed "milk collecting routes" in order to get sufficiently large supplies. In addition to the

amount paid by the producers for hauling (usually so much per can or per gallon), the dealers sometimes pay the route men a bonus of from $2.00 to $5.00 per trip.

FIG. 46.—Hauling milk to railroad station.

Cost of Hauling.—Table 45 shows a summary for 204 individual producers of costs of hauling to country receiving stations in New York State. (15)

In Table 46 are shown the rates charged for hauling milk to receiving stations in New York State. (15) In the case of 69 routes most of the milk was picked up at the farms; in the case of 7 routes most of the milk was picked up at shipping platforms, very few stops being made.

Table 48 shows a summary of costs of hauling milk on commercial routes to receiving stations in New York State. (15)

Fig. 47 shows the relation of the size of load to cost of hauling 100 pounds of milk on commercial routes. (15) As the size of the load increases, the cost per 100 pounds constantly decreases.

TABLE 45

Costs of Hauling Milk by Individual Dairymen (15)

	Dairymen Using Chiefly		All Dairymen.
	Horses.	Automobiles or Trucks.	
Number	115	89	204
Average hauling distance (miles):			
Improved road	1.1	1.8	1.4
Unimproved road	1.1	1.0	1.1
Total	2.2	2.8	2.5
Average number of trips:			
With one horse	275	58	181
With two horses	42	22	34
With automobile or truck	5	252	112
Total	322	332	327
Hours per trip:			
With horses	1.2	1.6	1.3
With truck	0.7	0.6	0.6
Cost per trip:			
All trips	$0.716	$0.801	$0.754
Trips with horses:			
Human labor	$0.383	$0.494	$0.401
Horse labor	$0.256	$0.353	$0.272
Wagon and harness	$0.075	$0.104	$0.080
Total for trips with horses	$0.714	$0.951	$0.753
Trips with truck:			
Human labor	$0.222	$0.200	$0.201
Use of truck	$0.566	$0.554	$0.554
Total for trips with truck	$0.788	$0.754	$0.755
Pounds of milk per trip	273	340	302
Cost per 100 pounds of milk	$0.263	$0.236	$0.249

"The average cost per trip was 71.6 cents for the dairymen who used horses and wagons, and 80.1 cents for those who used automobiles or trucks. The latter group had 0.6 mile longer haul, and somewhat larger loads.

"The average cost per 100 pounds of milk was 26.3 cents for the dairymen who used horses, and 23.6 cents for those who used trucks." (15)

TABLE 46

RATES CHARGED FOR HAULING MILK ON COMMERCIAL ROUTES (15)

Miles from Farm to Milk Station.		Number of Farms.	Rate Charged for Hauling (Cents per 100 Pounds).		Hauling from Farms to Platform.	
Range.	Average.		Range.	Average.	Number of Farms.	Average Distance, Miles.
Routes on which most of the milk was picked up at the farm						
1 or less	0.7	12	8 to 20.0	12.3	0	0
1.1 to 2	1.7	59	6 to 23.0	12.5	4	0.6
2.1 to 3	2.7	98	6 to 25.0	13.2	7	0.5
3.1 to 4	3.6	129	6 to 27.0	14.5	21	0.6
4.1 to 5	4.7	124	6 to 25.0	15.6	27	0.9
5.1 to 6	5.6	139	8 to 27.5	17.0	42	1.0
6.1 to 7	6.6	113	10 to 25.0	17.7	35	1.1
7.1 to 8	7.6	89	10 to 27.5	19.1	27	1.1
8.1 to 9	8.7	88	13 to 27.5	21.0	16	0.9
9.1 to 10	9.6	59	13 to 27.0	21.5	17	1.4
10.1 to 12	10.9	71	15 to 27.5	24.0	23	1.3
More than 12	13.1	26	15 to 27.5	26.6	12	1.2
All farms	6.0	1,007	6 to 27.5	17.3	231	1.0
Routes on which most of the milk was picked up at platforms						
1 or less	0.5	1	10.0	10.0	0	0
1.1 to 2	1.6	2	15 to 20.0	17.5	0	0
2.1 to 3	2.8	7	12 to 23.0	16.7	3	2.0
3.1 to 4	3.7	14	10 to 23.0	18.2	6	0.8
4.1 to 5	4.6	13	10 to 23.0	16.0	9	0.7
5.1 to 6	5.7	25	10 to 23.0	15.7	19	1.1
6.1 to 7	6.7	24	10 to 15.0	13.0	18	1.2
7.1 to 8	7.6	37	10 to 23.0	12.2	33	1.0
8.1 to 9	8.6	27	10 to 15.0	11.3	25	1.7
9.1 to 10	9.5	8	10 to 23.0	13.4	5	2.2
10.1 to 12	11.0	14	10 to 15.0	13.6	13	1.6
More than 12	12.3	1	55.0	15.0	1	0.3
All farms	6.9	173	10 to 15.0	12.4	132	1.3

"In Table 47 the average rates charged by the commercial haulers who picked up milk chiefly at the farm are compared with the average costs of hauling by individual dairymen. For dairymen located only 1 mile or less from the point of delivery, the cost of individual hauling was about the same as the average rate charged by commercial haulers. For longer hauls the rates for commercial hauling were considerably lower than the costs of individual hauling. For all distances exceeding 4 miles, the rates for commercial hauling averaged only half as much as the costs of individual hauling, although the average hauling distance was greater on the commercial routes." (15)

TABLE 47

COSTS OF INDIVIDUAL HAULING, AND RATES CHARGED BY COMMERCIAL HAULERS (15)

Distance to Point of Delivery.	204 Dairymen.	69 Commercial Routes.
	Cents per 100 Pounds.	
1 mile or less	12.6	12.3
1.1 to 2 miles	20.0	12.5
2.1 to 3 miles	23.8	13.2
3.1 to 4 miles	27.1	14.5
More than 4 miles	41.1	20.0

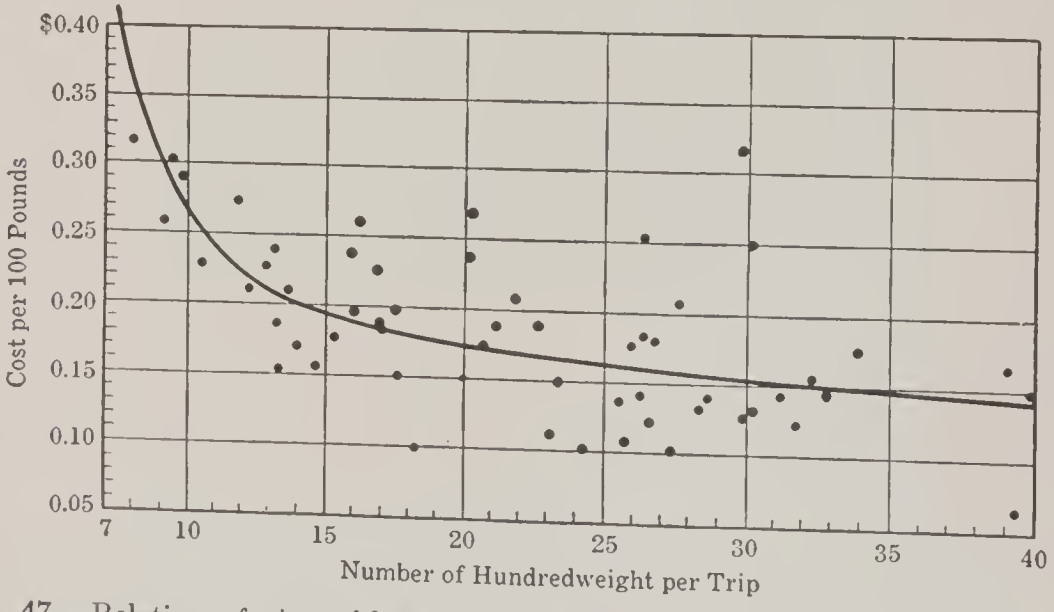


FIG. 47.—Relation of size of load to cost of hauling 100 pounds of milk on commercial routes. (15) The positions of the dots show the cost per hundredweight and the average size of load for individual routes. The curved line indicates the tendency for hauling costs to decrease as the size of load increases. In general, the cost increases rapidly when the loads fall below 15 hundredweight of milk per trip.

TABLE 48

SUMMARY OF COSTS OF HAULING MILK ON COMMERCIAL ROUTES (15)

	Haulers Using Horses.	Haulers Using Trucks.	All Haulers.
Number of haulers	17	59	6
Number of patrons per route	13	16	15
Number of stops per trip	11	12	12
Number of "pick-ups" at door	11	11	11
Number of patrons delivering at platforms	2	5	4
Average haul to platform (miles)	1.1	1.1	1.1
Number of trips in a year:			
With horses	368	79	144
With trucks	.....	364	283
Total	368	443	427
Average haul (miles):			
Improved road	1.9	5.5	4.9
Unimproved road	2.2	1.8	1.9
Total	4.1	7.3	6.8
Number of miles per trip	11.2	17.2	16.1
Average load (hundredweight)	17.0	21.8	20.9
Cost per trip:			
All trips	$3.03	$3.78	$3.64
Trips with team:			
Driver	$1.46	$2.24	$1.60
Horse labor	$1.36	$1.90	$1.45
Wagon and harness	$0.21	$0.32	$0.23
Total for trips with team	$3.03	$4.46	$3.28
Trips with truck:			
Driver	.....	$1.15	$1.15
Use of truck	.....	$2.47	$2.47
Total for trips with truck	.....	$3.62	$3.62
Cost per hundredweight	$0.1777	$0.1729	$0.1736
Cost per hundredweight-mile	$0.0427	$0.0239	$0.0257
Income per trip	$2.37	$3.86	$3.57
Income per hundredweight	$0.1392	$0.1769	$0.1709
Net return per hour of human labor	$0.1568	$0.4338	$0.3734

Shipping Stations.—Where milk is transported, by steam or electric roads, by direct shipment, it is brought to the " station," from which it is put on the train when it arrives. These stations may be anything from a small platform (the same height as the floor of the car) to a well-constructed shed beside the railroad tracks. The farmers or haulers unload the milk from the wagons to the platform before the arrival of

the train, and when the train arrives they put the cans of milk into the car. Usually at least two of the producers remain at the station

FIG. 48.—Milk receiving platform at a city railroad terminal.

for this purpose till the train comes in, but in some localities where special milk trains are operated, the railroad companies furnish the man to put the milk into the car from the platform. In all cases

FIG. 49.—A milk shipping platform with canvas sun curtain.

there is a railroad man on the car to see to the placing of the milk in the car.

Delays at the Station.—While the farmer intends to deliver the milk at the station platform shortly before train time, where milk is transported by direct shipments, it is, nevertheless, often left exposed to the sun for considerable time. Again when it arrives in the city, it is sometimes left exposed on the city platform. Country shipping platforms should be covered, wherever possible, to protect the milk from the sun.

TANK CAR TRANSPORTATION

A recently developed method of shipment from the country receiving station to the city is by means of glass- or metal-lined tanks mounted

FIG. 50.—Milk producers loading milk cars at a country shipping point.

on railroad cars. This system of transportation has proved very satisfactory and is fast growing in popularity, especially for long hauls. In a few cases the tank cars are switched directly from the railroad yards to

FIG. 51.—A more elaborate milk shipping station.

the dealer's city plant, but in most cases the city plant is so located that this would not be practicable and the dealer must draw the milk from the tank car on arrival at the terminal yards into tank trucks and transfer it to his city plant, where it is drawn off into storage tanks in the plant either by gravity, a pump, or compressed air.

In 1907 there were three tank cars, each having a capacity of 3120 gallons, in use by two Boston milk companies. (2) This is probably the first time that tanks were used in the transportation of milk by railroad. Two of these tanks were in continuous use for five years; the other is still in use, averaging one round trip of 280 miles every fifth day between a country-shipping station and the city plant.

In May, 1927, there were 62 milk tank cars transporting milk into Chicago, 5 into New York City, 2 into New Orleans, 8 into Pittsburgh, and 8 into Philadelphia. (3) The distances milk is transported into Chicago by these tank cars vary from 51 to 361 miles. At the present time there are nearly 200 tank cars in the Chicago area and about 75 in the New York City area.

Nearly all milk tank cars are built alike. Each car contains two steel metal- or glass-lined tanks of from 2000 to 3000 gallons each, making a total capacity of from 4000 to 6000 gallons. This is about double the capacity of the ordinary milk refrigerator car which transports milk in cans. The tanks are cork-insulated and steel-jacketed. In all cases the car itself is insulated, and the milk can be transported many miles with a loss of only one or two degrees in temperature. Great economies are effected by the use of this system of transportation. The milk arrives in better condition than it does when shipped in cans, and there is no handling of cans. It takes only a few minutes to wash the tanks, whereas the washing of the number of cans required to ship an equivalent quantity of milk is a big job. Where this method of transportation is used the shipper (milk dealer) either buys the car or leases it from the manufacturers. The cost of these cars is about $14,000 each.

Tank-car shipments are especially suited where the city plant is located on the railroad siding and where the dealer receives his supply from a country receiving station which is located on the railroad and which supplies enough milk to fill a car. In the Chicago district the minimum load quoted by the railroad is 40,000 pounds, so that not all dealers can make use of this type of transportation, for even though both their city plant and country plant are located on the railroad, they might not have an amount of milk adequate to fill a car.

The tank car tends to extend the limits of the " milk shed " by providing relatively cheap transportation from distant points. Several of these tank cars are now operated from districts which have never before shipped market milk. The railroads are willing to quote reduced rates as compared to transportation in cans because the capacity of the car, which is about 51,000 pounds, is more than twice the capacity of the cars used in transporting milk in cans. The freight rate into Chicago is approximately 60 per cent of the can rate for an equivalent quantity

of milk. The rate from one point in Wisconsin in 1925 was 27 cents per 100 pounds in tank cars and 45 cents per 100 pounds in 10-gallon cans. (12)

During the winter tourist season shipments by tank car have been made regularly from Wisconsin to Miami, Florida, the milk arriving in first-class condition.

TRANSPORTATION BY TRUCK

In many localities milk is brought by truck either directly from the producer's farm or from the country receiving station to the dealer's plant in the city. Where the distance is not great this is a good system; there are no transfers to be made either in the country or at the city to and from railroad depots or yards. Where the roads are good, milk may be shipped economically for considerable distances by this system.

According to Erdman (4) 56 per cent of the milk supply of Milwaukee in 1916 was brought into the city by wagon or auto truck. By 1924 (5) this percentage had increased to 87.5, and consisted entirely of auto truck transportation, as is shown in Table 49.

TABLE 49

NUMBER AND PER CENT OF CANS TRANSPORTED DAILY BY RAIL AND MOTOR TRUCK, MILWAUKEE AREA, 1924. (5)

	Number of Cans.	Per Cent.
Motor truck	7352	87.5
Electric railroad	1055	12.0
Steam railroad	50	.5
Total	8457	100.0

The trucks which bring milk into the city are either operated by the producers themselves, the dealers, or by paid haulers. In Table 50 are shown the costs of trucking milk to Detroit, Michigan, in 1915 as compared with the freight rates on steam and electric roads from certain stations for distances up to 25 miles. (6)

Thus, for these particular distances the truck system cost less than shipping by steam railroad. The cost was slightly less by the electric railroad, but it must be remembered that where trucks are used for transporting milk they bring it directly to the dealer's plant in the city,

TABLE 50

Cost of Trucking Milk Compared with Rail Transportation Rates. (6)

Number of Station.	Average Number Cans Hauled Daily.	Distance, Miles.	Comparative Transportation. Costs per Can.		
			Trucks.	Steam Roads.	Electric Roads.
1	30.7	12	$0.15	0$.20	$0.15
2	31.6	12	.15	.20	.15
3	46.5	12	.15	.20	.15
4	40.5	15	.175	.20	.15
5	112.5	15	.175	.20	.15
6	49.4	20	.175	.20	.15
7	41.1	25	.175	.20	.15
8	43.7	25	.175	.20	.15
Average....	49.5	17	$0.1656	$0.20	$0.15

whereas in the case of transportation by steam or electric railroad the dealer must pay for trucking the milk from the terminal or yards to the plant in addition to the freight charges. In some cases, also, the milk must be trucked from the receiving station in the country to the railroad, although where milk is to be shipped by rail the shipping station should always be built beside the railroad tracks.

Table 51 shows samples of motor truck rates existing in 1924 in Detroit. (5)

TABLE 51

Typical Motor Truck Rates, Detroit Area (5)

Station.	Distance in Miles.	Rate, Cents per 100 Pounds.
1	30.0	27
2	53.5	50
3	30.0	27
4	21.0	24
5	38.0	30
6	27.3	45
7	25.5	45
8	34.0	45

The can of milk mentioned in Table 50 holds approximately 85 pounds. By comparing Table 50 with Table 51 and keeping the fact in mind that 100 pounds of milk is only slightly more than one can, it will be noted that the costs of trucking have increased considerably and also that they were much more uniform in relation to distance in 1924 than in 1915. Two factors account for this change: (1) In 1915 all the milk was trucked in cans whereas in 1924 most of it was trucked in tank trucks. Although less weight is carried with the latter system, a larger investment in trucks is required. (2) In 1915 trucking of milk was not an important business and there was no systemized method of making charges, whereas in 1924 the trucking of milk had become an important business and systematic rates had become imperative. By 1924 a large portion of the milk was transported by one concern, which had invested in a large fleet of tank trucks costing several hundreds of thousands of dollars. According to the Bureau of Public Roads (5) the truck rates are graded in such a manner as to approximate a charge of 1 cent per 100 pounds per mile. Furthermore, according to their report this same rate also applied in general to milk trucked in cans as well as that transported by tank truck.

In July, 1915, (6) the quantities of milk shipped into Detroit, Michigan, by various agencies were as shown in Table 52.

TABLE 52

Quantities of Milk Received in Detroit During July, 1915 (6)

Means of Transportation.	Gallons.	Per Cent of Total.
Steam railroads	630,990	41.8
Electric railroads	637,860	42.3
Teams or automobile trucks	239,780	15.9
Total	1,508,630	100.0

In February, 1924, according to the U. S. Bureau of Public Roads, (5) the quantities shipped by various agencies were as shown in Table 53.

Thus from July, 1915, to February, 1924, the amount of milk shipped into Detroit had increased from 12,823,355 to 35,784,690 pounds per month, and the amount shipped by motor truck and wagon in 1915, 2,038,130 pounds, had increased to 31,743,690 pounds in 1924. Of the total milk shipped into Detroit, 15.9 per cent was shipped by motor

TABLE 53

MILK TRANSPORTED BY DIFFERENT AGENCIES TO DETROIT IN FEBRUARY, 1924 (5)

	Pounds.	Per Cent of Total.
Steam railroads	775,710	2.1
Electric railroads	3,265,290	9.1
Motor truck	31,743,690	88.8
Total	35,784,690	100.0

truck and wagons in 1915, whereas, of the greatly increased quantity of milk shipped in 1924, 88.8 per cent was shipped by auto truck. By 1924 wagon shipments had ceased entirely. A large proportion of the truck shipments in 1924 were by tank truck, whereas in 1915 all milk was handled in cans. The percentage of milk shipped into Detroit by steam railroad decreased from 41.8 per cent in 1915 to 2.1 per cent in 1924; the percentage shipped by electric railroads decreased from 42.3 per cent to 9.1 per cent.

Tables 52 and 53 clearly illustrate the tendency of the times where there are good roads and a supply of milk can be obtained at distances not prohibitive for truck transportation.

TANK TRUCK TRANSPORTATION

The transportation of milk in tank trucks is a recent development. (See Tables 52 and 53.) It is adapted for distances that are not prohibitive for truck hauls and for transporting from country receiving stations to the city plant, especially when neither the country nor city plant is located along the railroad tracks.

Metal tanks mounted on motor trucks were first used for transporting milk in California in 1912. (2)

This system is practicable only where a full load can be picked up at one station, although it is sometimes possible to fill out the load from another plant as is done in the case of the tank car in some instances. It cannot, however, be used for " pick-up " service as the term is generally understood. Besides the regular truck, trailers and semi-trailers are used. By the use of trailers and semi-trailers a greater load can be carried without exceeding the highway weight limit. The capacity of the tanks varies from 800 to 2000 gallons, 1250 gallons being the most common size.

Sometimes the tank trucks are owned by the milk dealer, but in many cases they are owned by haulers who haul the milk to the city on a contract basis or so much per hundred weight. In the Chicago district many country bottling plants have been converted into receiving stations adapted to preparing milk for shipment in tank trucks. The reasons for this are the higher rail rates on bottled milk and the fact that there are good hard-surfaced roads leading to the city. Furthermore, in many cases, the dealer is enabled to deliver his milk to the customer fresher where this system of transportation is used as compared to shipping in cans by the railroad. The dealer is not dependent on train schedules and the tank truck is filled at the country station as soon as the milk has been received from the producers and cooled. This is usually about 10 or 11 A.M. The milk reaches the city in the afternoon and the truck returns to the country, ready for the next day's load. In some cases the trucks leave the country earlier in the morning and arrive in the city before noon. The cost of the trucks varies according to capacity, etc., but a fair average cost is $6000, so that for short distances the cost of the equipment is less than is required for tank-car transportation. The tank truck is flexible for handling the variable amounts of milk produced at different seasons. When the production falls off the dealer can simply suspend the use of a trailer or of a truck during the short season. Truck rates are usually based on distance (see Table 51), and more so than are the railroad rates for the first 30 miles or so, as in the case of the railroads the terminal costs must be included. The rates for truck hauling are usually higher when the route follows poor roads.

TABLE 54

COMPARISON OF THE RESULTS AS TO TIME AND LABOR REQUIRED AT CITY MILK PLANTS RECEIVING MILK IN CANS AND FROM TANK CARS OR TANK TRUCKS (17)

System.	Number of Plants.	Average Daily Receipts. Gals.	Average Number of Men.	Average Time Required.		Average Receipts.		Average Time Required to Receive 100 Gallons. Minutes.	
				Hours.	Man-hours.	Per Hour. Gals.	Per Man-hour. Gals.		
						*	*	†	*
In cans from trucks.	91	7328	3.9	4.9	19.1	1565	384	5.7	3.8
From tank trucks or cars.....	24	8102	1.5	4.4	6.2	1834	1309	3.7	3.3

* Weighted average. † Average of averages.

ECONOMY OF BULK TRANSPORTATION OF MILK

In general, considerable economies can be effected by shipping milk in tank cars or tank trucks as compared with shipping in cans. Both the tank-truck and the tank-car systems are fast gaining in popularity. Not only does the milk arrive in the city, in some cases, fresher, and with the loss of often less than 2 degrees in temperature, but also great savings in handling are effected with the bulk-shipment method. No cans have to be handled or washed, either at the country or the city end.

Table 54 shows a comparison of the labor used at 91 city milk plants receiving milk in cans with 24 plants receiving from tank cars or tank trucks. The labor used in washing the cans and the tanks is included.

TRANSPORTATION BY ELECTRIC CARS

Before the advent of the motor truck and especially of the tank truck, considerable quantities of milk were transported by electric railroads. In July, 1915, 42.3 per cent of the milk shipped into Detroit was transported by electric cars. (6) By 1924 only 9.1 per cent was received by electric cars, (5) owing to the increase of motor truck transportation. In 1916, according to Parker, (1) Chicago received 5 per cent of its supply over electric roads, Cleveland 45 per cent, and Indianapolis 68 per

TABLE 55

Comparison of Transportation Rates on Electric and Steam Railways in the Detroit Market Milk Territory during the Year 1915 (6)

Rates per 10-gallon Can.	Distance, in Miles, for which Rates Apply.			
	Detroit United Railways (Electric).	Pere Marquette Railroad.	Michigan Central Railroad.	Grand Trunk Railroad.
$0.15	1–30	1–25	1–25	1–17
.20	.....	1–25	1–25	18–55
.21	.....	26–30	26–30	.....
.22	31–35	31–35	31–35	.....
.23	36–40	36–40	36–40	.....
.24	41–45	41–45	41–45	.....
.25	46–50	46–50	46–50	56–75
.26	51–60	51–60	51–60	.....
.27	61–70	61–70	61–70	.....
.28	71–80	71–80	71–80	.....
.29	81–90	81–90	81–90	.....
.30	91–100	91–100	91–100	76–100

cent. In 1924, according to the Bureau of Public Roads, (5) Indianapolis received only 6 per cent of its supply over the electric roads, and the entire remainder of 94 per cent was received by motor truck. The change from electric-car service to motor trucks was due in a large measure to the fact that the motor trucks furnish complete service; i.e., they pick up the milk either at the farm or the country station and deliver it direct to the city plant with no intermediate hauling as is usually required with electric or steam transportation.

Table 55 shows the comparative rates by steam and electric roads to Detroit in 1915.

REFERENCES

(1) Parker, H. N., City Milk Supply. McGraw-Hill Book Co., New York, 1917.
(2) Smith, R. S., Transportation of Milk in Metal Tanks. 11th Annual Report Int. Assoc. of Dairy and Milk Inspectors.
(3) Schoenfeld, W. A., Some Economic Aspects of the Marketing of Milk and Cream in New England. U. S. Dept. Agri. Circular 16.
(4) Erdman, H. E., The Marketing of Whole Milk. Macmillan Co., 1921.
(5) Public Roads. U. S. Dept. Agri., Bureau of Public Roads, Vol. 5, No. 5, July, 1924.
(6) Clement, C. E., and Warber, G. P., Market Milk Business of Detroit, Michigan, in 1915. U. S. Dept. Agri. Bul. 639.
(7) Merritt, Eugene, The Production and Consumption of Dairy Products. U. S. Dept. Agri. Bul. 177, 1918.
(8) Records of the Dairy Division of the Chicago Health Department.
(9) McFall, R. J., The New England Dairy Market. U. S. Dept. Agri. Bur. of Agri. Economics, mimeographed report, 1925.
(10) Interstate Commerce Commission I. & S. Docket No. 725, New England Milk Case, 1916.
(11) Gamble, J. A., and Bowen, J. T., Cooling Milk and Storing and Shipping it at Low Temperatures. U. S. Dept. Agri. Bul. 744, 1919.
(12) Public Roads. Bur. of Public Roads, U. S. Dept. Agri., Vol. 6, No. 5, July, 1925.
(13) American Creamery and Poultry Review, New York, June 25, 1930.
(14) Monthly Milk and Cream Market Reports. U. S. Dept. Agri., Bur. of Agri. Economics, June, 1930.
(15) Spencer, Leland, An Economic Study of the Collection of Milk at Country Plants in New York. Cornell Agri. Exp. Sta. Bul. 486, 1929.
(16) Brown, C. A. Costs and Margins and Other Related Factors in the Distribution of Fluid Milk in Four Illinois Market Areas. Ill. Agri. Exp. Sta. Bul. 318, 1928.
(17) Clement, C. E., Le Fevre, P. E., Bain, J. B., and Grant, F. M. Effect of Plant Arrangement and Methods of Operation on Labor Requirements. U. S. Dept. Agri. Tech. Bul. 153, 1929.
Horner, J. T., The Detroit Milk Market. Mich. Agri. Exp. Sta. Special Bul. 170, 1928.
(18) Whitaker, Geo. M., The Milk Supply of Boston and Other New England Cities. U. S. Dept. Agri. B. A. I. Bull. 20, 1898.

CHAPTER XV

COUNTRY MILK-RECEIVING STATIONS

To provide a means for assembling and cooling the milk before shipment to the city, country milk-receiving and cooling stations have been established either by producers' organizations or by the city distributors of milk, at points varying from less than 30 miles to more than 400 miles from the city.

FUNCTIONS OF COUNTRY MILK-RECEIVING STATION

The principal function of a country milk-receiving station is to furnish a place where the milk from the producers can be received, weighed, cooled, and shipped to the city market. The milk as received from the producers is immediately weighed and cooled, and the producers' cans, after being washed, are returned to him. With this system, cans of milk are not left exposed on a shipping platform, as the milk is cooled as soon as it arrives from the producers' dairy and prepared for shipment so that it arrives in the city in good condition. The testing and grading of the milk are facilitated by this system, and any surplus milk can be held in the country to be manufactured into by-products, thus effecting a considerable saving in transportation costs. Among other advantages of this system of shipping milk as compared with direct shipments are the following:

1. Less can cost to the producer.
2. Less likelihood of cans being lost.
3. The producer need not cool the morning's milk, provided it reaches the station shortly after milking.
4. Assists in developing dairying.
5. Payments to producer are direct and more prompt.
6. The producer can see his milk weighed, and there is less likelihood for disputes as to tests.
7. Closer contact between the producer and the distributor.
8. The station operator can keep a close check on the quality of the milk that is received from each producer and can often assist him in improving the quality of his product, as well as in the problems of economincal milk production.
9. Permits longer shipments of milk and a better quality to reach the city.

OWNERSHIP OF COUNTRY RECEIVING STATIONS

In most cases the stations are owned by the milk distributors, but in some sections they are owned and operated by the producers' organizations. When the stations are under the control of the producers, they usually handle the surplus. When the stations are owned by the distributors, the producers are relieved of the responsibility of handling the surplus, but they do not have so great a bargaining power, when prices are being negotiated, as the producers who control the stations themselves.[1]

LOCATION OF COUNTRY MILK-RECEIVING STATIONS

The following are among the points that should be considered in choosing a location:

1. Nearness to a sufficient number of dairy cows to insure a supply adequate for a station of economical capacity at all seasons.
2. Proper shipping facilities.
3. Water supply and sewage disposal.
4. Competition.

Nearness to Sufficient Number of Dairy Cows.—It is desirable that long hauls are not required to bring the milk to the station, as they add to the expense and also may result in the milk getting to the station in poor condition.

In order that long hauls may be avoided and that there be a plentiful supply of milk, it is obvious that the station should be located in a good dairy section. In order for the station to be run economically, there should be available at least 10,000 pounds of milk daily. (See Tables 58 and 59, pages 230 and 231.) The length of haul that would be permissible will depend on the type of roads and the quantity of milk available. Unless the roads are good, it is desirable to have a sufficient supply within a radius of 5 to 8 miles. Where there are good hard-surfaced roads, considerably greater distances can be covered by auto trucks, provided there is a sufficient supply to insure a paying load. In many cases the production of milk can be increased so that it may be desirable to establish a station even though there is not immediately available a sufficient supply for economical plant operation, with the idea in view of increasing the production per farm and developing dairying in the area. Many milk dealers are doing valuable work along this line.

Proper Shipping Facilities.—If the milk is to be shipped by rail, the station should be located on the railroad so that the milk may be trans-

[1] See Chapter XIII.

ferred directly to the cars. Where trucks are used to transport the milk to the city, the station should be located close to a good road. Even where trucks are used to transport the milk, however, it is a good plan to locate in the vicinity of a railroad if possible in case anything happens to the truck transportation system. This factor may be of considerable importance in sections where serious snow storms and blizzards are common.

Water Supply.—An adequate water supply is necessary for the successful operation of a milk-receiving station. The water used for cleaning purposes must be pure and uncontaminated. It is also desirable that the water be as cold as possible so that much of the cooling of the milk may be accomplished with it. A survey of 185 stations by the Bureau of Dairy Industry showed that the systems used to procure water were as follows:

	Stations.
Own well (usually driven well)	145
City water	27
Own well and city water	6
Spring	3
Well and spring	3
River and well	1

It will be noted that most of the plants had their own wells. City water is quite expensive when a large quantity is used. It is therefore desirable for a milk-receiving station to have its own well and to have it deep enough to provide an ample supply of cold water at all times. Although water from a stream might be used for cooling purposes, it should not be used for washing cans and equipment because of the possibility of contamination.

Sewage Disposal.—Sewage disposal is an important problem. The following tabulation shows the systems of sewage disposal used at 108 plants:

City sewer	28
Piped to creek or river	26
Cesspool	12
Septic tank	11
Cesspool to creek	11
Open ditch	7
Septic tank to creek	4
Drain to creek	4
Piped to ditch	3
Piped to open field	2

The use of a city sewer is of course desirable, but this is often impossible. Deposit of the sewage in a stream is not desirable unless there is

a large body of water. Where a large stream is available, it may be used provided there are no laws prohibiting the emptying of sewage into it. Septic tanks or cesspools are often used where neither a city sewer nor a flowing stream is available. If the soil is porous, as in the case of gravel soil, the cesspool may be satisfactory; but the septic tank usually gives better satisfaction, especially if there is much casein or albumen in the sewage. Septic tanks will give the best results if the quantity of sewage supplied is uniform in amount from day to day and the size of the tank is regulated according to the quantity of sewage to be handled. Cesspools are not satisfactory except where the soil is porous.

Competition.—Competition is an important item to be considered in the location of the plant. If the plant is located near that of a competing company, not only may difficulties arise between the two companies but the volume of milk that can be obtained would probably be too small for the most economical plant operation. Competition from other city markets should also be considered, and the plant should preferably not be located near the territory that would normally be drawn upon by other cities. Not only would this cause a division of the supply between the two markets so that the volume per plant would be low, but there might be a difference in the prices paid by the two markets, which at certain times might result in the loss of many patrons who would naturally seek the higher-priced market.

It is not desirable to locate the plant too near the city, for as the city grows the milk-producing area will gradually be pushed away from the city by other industries and interests. Furthermore, with the increase of good roads, stations located too near the city are subject to the competition of direct haulers from the producer to the city plants. This competition may be an especially important factor during the season of milk shortage.

In some sections of the country, stations have been established in large numbers quite close to each other. The original cause for this was usually the fact that several competing companies established stations in the same producing area. Later several of these stations would sometimes fall into the hands of one organization and be consolidated into one plant because of the excessive per unit costs of operating the stations separately and the economies in plant operation that could be effected by combining the operations into one plant.

All factors considered, it is desirable to locate the station in an area that is either a good dairy section or that can be developed into one, and that, if possible, is at a sufficient distance away so that competition will not be an important factor. Improved roads, automobile hauling, and better railroad service permit longer hauls both for getting

the milk from the producer to the plant and from the plant to the city, than was formerly the case.

The selection of a distant location for the station is often desirable because such areas have a chance to grow with the growth of the city and the increased demands for milk.

CONSTRUCTION OF BUILDING

The most desirable material to use in the construction of the plant will depend somewhat on local conditions. Brick, concrete, stone blocks, or tile are durable and have some advantages over frame buildings. They are more nearly fireproof; they are warmer in winter and cooler in summer, and the cost of upkeep and repairs is much less. Frame buildings, however, are very popular because of the low initial investment, though the cost for upkeep and repairs is much greater.

TABLE 56

MATERIAL USED IN CONSTRUCTION OF 123 COUNTRY RECEIVING STATIONS

Size of Plants Pounds Received Daily.	Frame.		Cement Blocks.		Glazed Tile.		Brick.	
	Number of Plants.	Average Pounds Handled.	Number of Plants.	Average Pounds Handled.	Number of Plants.	Average Pounds Handled.	Number of Plants.	Average Pounds Handled.
Less than 10,000...	26	6,258	7	7,449	5	7,459	3	9,320
10,001 to 20,000....	36	14,750	3	13,621	1	16,482	6	16,419
Over 20,000.....	16	26,139	4	32,188	1	71,000	4	28,510
Total or average....	78	14,181	14	13,541	7	17,825	13	18,501

Size of Plants. Pounds Received Daily.	Brick and Concrete.		Frame and Concrete.		Stone.		Steel and Concrete.	
	Number of Plants.	Average Pounds Handled.	Number of Plants.	Average Pounds Handled.	Number of Plants.	Average Pounds Handled.	Number of Plants.	Average Pounds Handled.
Less than 10,000...	.....	.....	.....	.....	.....	.....	.....	.....
10,001 to 20,000....	1	19,000	4	13,872	1	15,900	1	12,000
Over 20,000.....	.....	.....	.....	.....	2	45,000	2	72,500
Total or average....	1	19,000	4	13,872	3	35,300	3	52,233

Table 56 gives the results of a survey made at 123 plants by the Bureau of Dairy Industry. It will be noted that the frame buildings were the most common for plants of all sizes. Cement block and brick were the next most popular materials used. Although brick, concrete,

or stone is much more durable and requires much less expense for upkeep than frame buildings, the latter are entirely satisfactory. The floors, and also the walls for a distance of 3 or 4 feet above the floor, should be of concrete, tile, or other hard-surface material. The floors should be well drained. Drains should be located when the floor is laid to insure a correct slope of floor and should be properly trapped and connected to the sewer. All plants surveyed had concrete floors.

Good ventilation is essential for all milk plants in order to get rid of bad air and moisture and to insure pure air in the milk-handling room. It is usually desirable to pipe the exhaust from the can washer out of the building either through the roof or side of the building so that the steam and bad odors will escape. A survey of 105 milk-receiving stations showed that roof ventilators were used at 70 plants, skylights at 8 plants, while at 27 plants windows were depended upon entirely for ventilation. Roof ventilators are very satisfactory and not expensive, and they are desirable for all plants. These should be connected to the milk-handling rooms by flues.

ARRANGEMENT OF PLANT

The plant should be so arranged that the milk can be weighed in on one side of the building and shipped out at the opposite side.

The receiving deck, where the milk is received and weighed, should be raised to about the level of the floor of the ordinary truck so that the cans of milk can be readily unloaded from the truck. It is also desirable that there be a drop from the receiving deck to the milk-handling floor sufficient for the milk to flow from the weigh can to the receiving vat by gravity. This will depend somewhat on the equipment used, but usually 3 to 4 feet is sufficient. The receiving room should be so arranged that the producer can unload his milk at the receiving door and then drive on and receive the washed cans either from another door or from a conveyor leading from the can washer. The distance between the points where he unloads his milk and receives the cans should be sufficient to prevent any congestion or confusion when large and small loads follow each other at the receiving door. A conveyor leading from the can washer out of and alongside of the building for a considerable distance, will take care of this condition. A small shed or lean-to may be used for the boiler room and coal storage. This should be so located that no dust or contamination can get from it to the milk-handling room. Where the station is located on a railroad siding the boiler room and coal bins should be so arranged that the coal can be conveniently unloaded directly from the car. Ample storage space should be provided, and also space to do repair work.

Where mechanical refrigeration is not used, an ice house should of course be provided. Except in extreme northern sections of the country, however, mechanical refrigeration is generally provided for.

FIG. 52.—Producers unloading milk and loading cans at a country receiving station.

Table 57 shows the system of cooling milk used at 129 stations.

TABLE 57

SYSTEMS OF COOLING MILK USED AT 129 MILK-RECEIVING STATIONS

Size of Plant. Pounds Handled Daily	Total Number of Plants	Number of Plants Using:		
		Well Water.	Ice Water.	Direct Expansion Ammonia or Brine with Mechanical Refrigeration.
Less than 10.000	39	5	12	22
10,001–20,000	46	.....	15	31
20,001–30,000	22	.....	8	14
30,001–40,000	11	.....	2	9
Over 40,000	11	.....	.....	11
Total	129	5	37	87

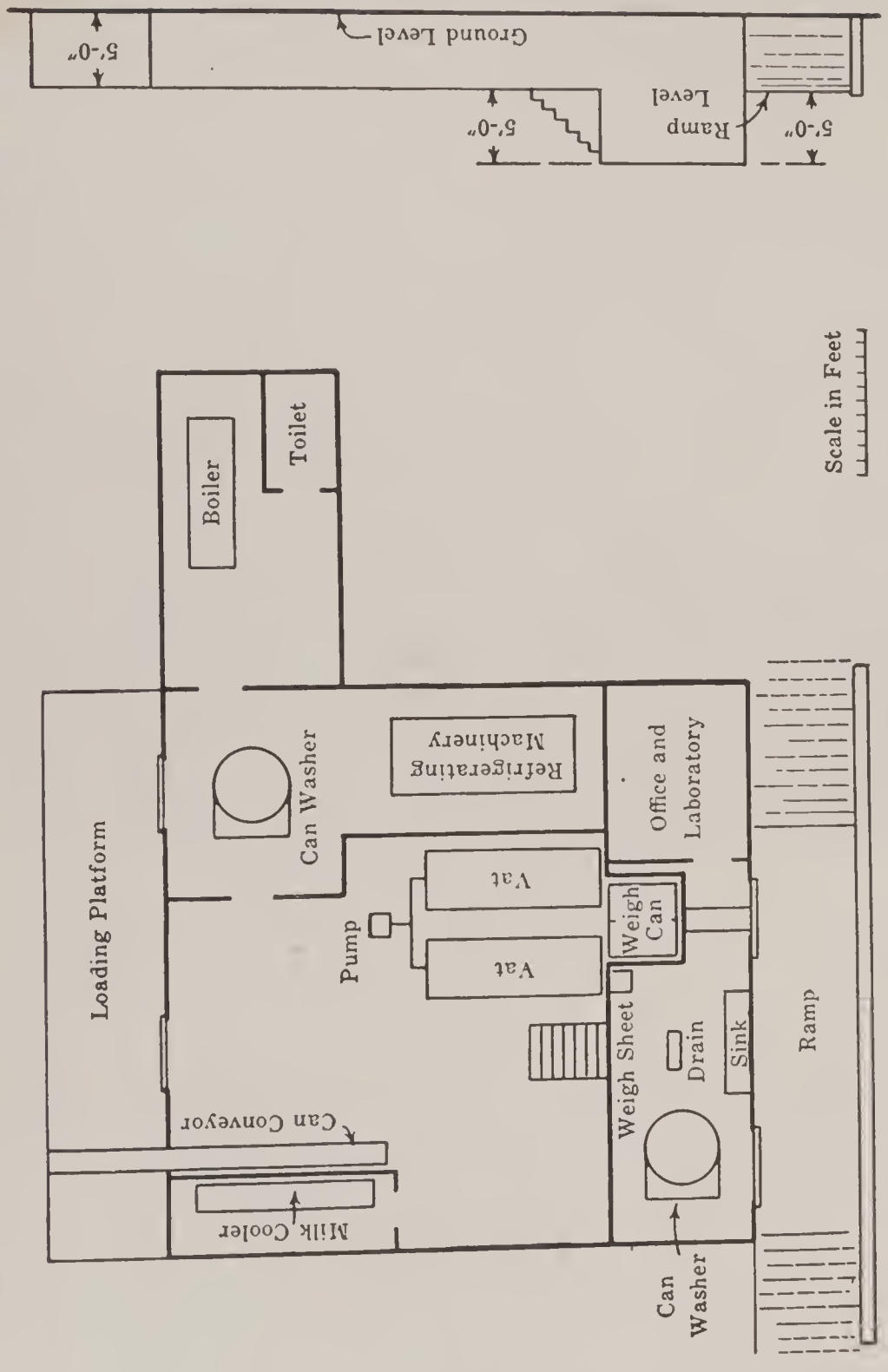


Fig. 53.—Floor plan for a receiving station of about 2500 gallons' daily capacity.

It will be noted that mechanical refrigeration was used at the majority of the stations.

Fig. 53 is a suggested floor plan for a receiving station of about 2500 gallons' daily capacity from which the milk is to be shipped in cans. Fig. 54 is a floor plan for a receiving station of about 4000 gallons' capacity with additional space to provide for the manufacture of surplus milk into by-products.

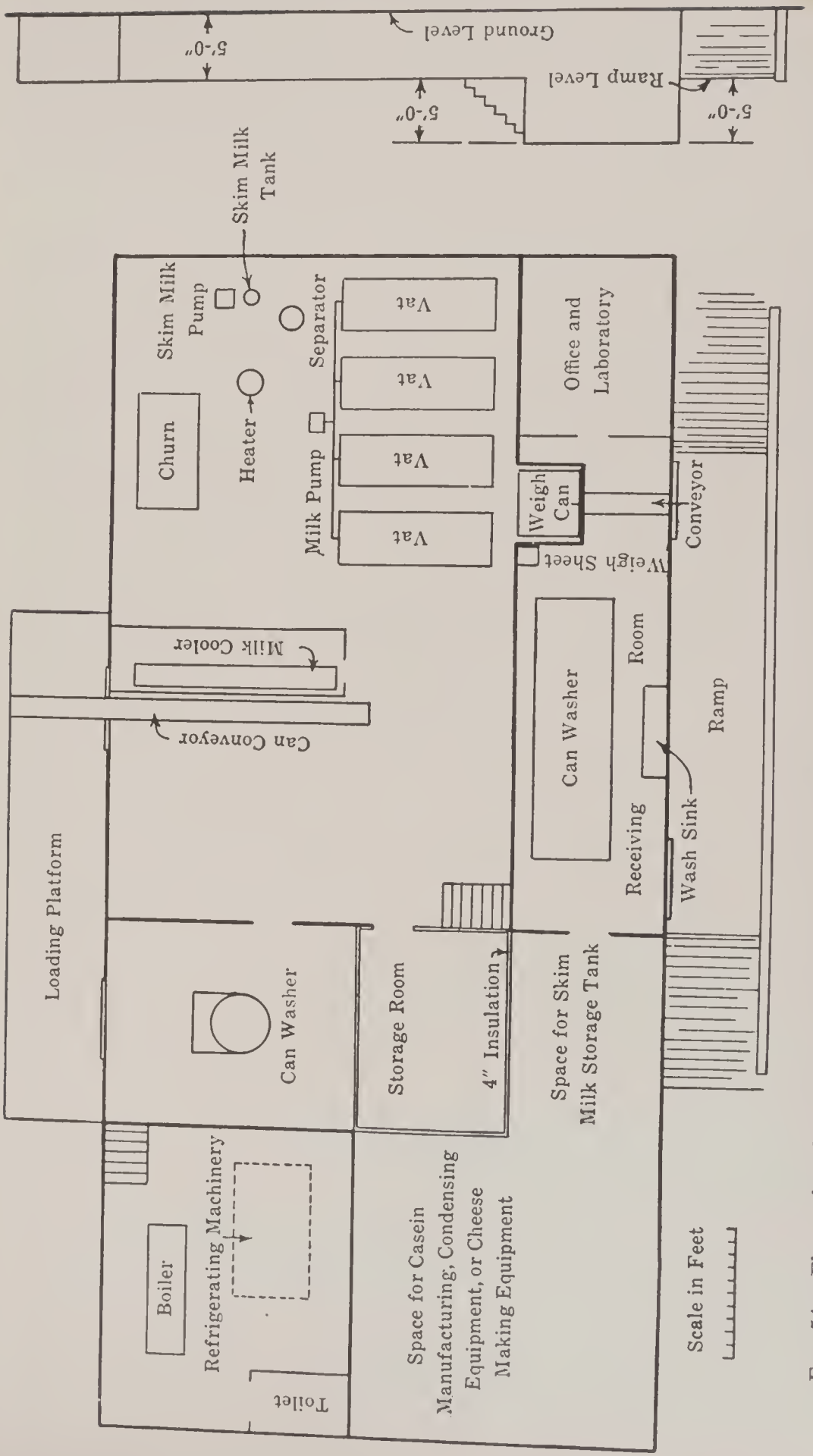


FIG. 54.—Floor plan for receiving station of about 4000 gallons' daily capacity with additional space for the manufacture of surplus milk into milk products.

Where milk is to be shipped in tank trucks or tank cars, the arrangement would be slightly different. No can washer need be provided for shipping-cans. The milk would either be pumped directly from the cooler to the tank truck or car, or to a storage tank from which it would later be transferred to the tank truck or tank car.

SUGGESTED LISTS OF EQUIPMENT FOR COUNTRY MILK STATIONS

The principal items of equipment required by the respective types of plants specified are enumerated in the following lists. Only approximate cost figures can be given, as costs will depend upon the type and quality of machinery purchased. In case city water is not used, additional equipment for pumping from a well must be provided. At each of the plants a certain quantity of general equipment and supplies will be required, such as brushes, tools, sample and test bottles, pipettes, thermometers, and office furnishings.

Receiving, Cooling, and Canning Station with Daily Capacity of 2500 *Gallons.—Principal Items of Equipment Required*

(Estimated cost, approximately $10,000)

One two-compartment weigh can, capacity 1000 pounds.
One dial scales, 1000 pounds capacity.
One milk-can drainer.
Two receiving and standardizing vats, capacity 400 gallons each.
One milk pump, capacity 8000 pounds per hour.
One milk cooler, capacity 8000 pounds per hour.
Two can washers.
One 36-bottle Babcock tester.
One 20-horsepower boiler with accessories.
One 10-ton compressor with accessories.
One insulated brine tank.
One brine pump with necessary piping.
One can filler.
One sink.
Necessary steam and water piping and fittings
Necessary sanitary piping and fittings.
Conveyors, motors, shafting, etc.

If equipment for artificial refrigeration is not provided the initial investment is reduced by about $2500 to $3000, but an ice house must be provided.

If some of the milk is to be separated and cream shipped, the following additional equipment would be required:

One separator, capacity 4500 pounds per hour.
One cream vat, with coils.
One can filler.
One skim-milk tank.
One skim-milk pump.
Total additional cost, $1500 to $2000.

Receiving, Cooling, and Canning Station with Daily Capacity of 4000 Gallons, and with Auxiliary Equipment for Manufacturing Milk Products.—Principal Equipment Required

(Estimated cost, $15,000 to $20,000)

One two-compartment weigh can, capacity 1000 pounds.
One dial scales.
Four vats with coils, 400 gallons capacity, for receiving, standardizing milk, cream storage, etc.
One milk pump, capacity 12,000 pounds per hour.
One milk cooler, capacity 12,000 pounds per hour.
One can filler for milk.
One milk heater.
One separator, capacity 4500 pounds per hour.
One skim-milk tank.
One skim-milk pump.
One skim-milk storage tank.
One can filler for cream (if cream is to be shipped).
Two can washers.
One can drainer.
One churn and butter worker, capacity about 600 pounds.
One 36-bottle Babcock tester.
One 50-horsepower boiler with accessories.
One 20-ton compressor with accessories.
One brine tank.
One brine pump, with necessary piping.
One sink.
Necessary steam and water piping and fittings.
Necessary sanitary piping and fittings.
Conveyors, motors, shafting, etc.

Auxiliary Equipment for Casein Manufacture

(Estimated cost of auxiliary equipment, approximately $1500 to $2000)

Precipitating vats.
Drying funnel, with fan blower and heating coils.
Drying trays and trucks.
Curd mill.
Curd press.
Press dividing boards.
Drain rack.
Cloths for draining and pressing the curd.

In some cases the wet curd itself is shipped; then only the precipitating vats, drain rack, curd press, dividing boards, and cloths for draining and pressing the curd are required.

If cheese is to be manufactured, two or three jacketed cheese vats, together with pressure cheese presses, are required, which will cost from $2000 to $3000.

Auxiliary Equipment for Condensing

(Estimated cost of auxiliary equipment, $7000 to $8000)

One 5-foot condensing pan.
Two hot wells, or one preheater and one hot well.
One vacuum pump.
Necessary piping and fitting.

The boiler horsepower would have to be increased if condensing is to be done.

Relation of Volume Handled to Operating Costs

Table 58 shows the cost of operation at 38 milk-receiving stations shipping milk to New York City. (1)

TABLE 58

Relation of Volume of Milk to Cost per 100 Pounds

	Volume of Milk Handled per Plant Annually.		
	Less than 4,000,000 Pounds.	From 4,000,000 to 8,000,000 Pounds.	Over 8,000,000 Pounds.
Number of plants	14	12	12
Average volume:			
Pounds per year	2,784,331	5,471,687	13,629,208
Cans per day	90	176	439
Total cost per 100 pounds milk (cents)	33.0	25.4	19.6

Figure 55 shows the relation of volume of milk received per plant to plant operating cost at 38 milk-receiving stations shipping to New York City. (1)

In Table 59 are given the operating costs for 13 milk-receiving stations of various sizes in Vermont. (2)

TABLE 59

Relation of Volume of Milk to Cost per 100 Pounds

	Average Annual Receipts in Pounds.		
	4,229,000.	5,934,000.	10,873,000.
Number of plants	4	5	4
Total cost of operation per 100 pounds (cents)	29.07	20.65	18.70

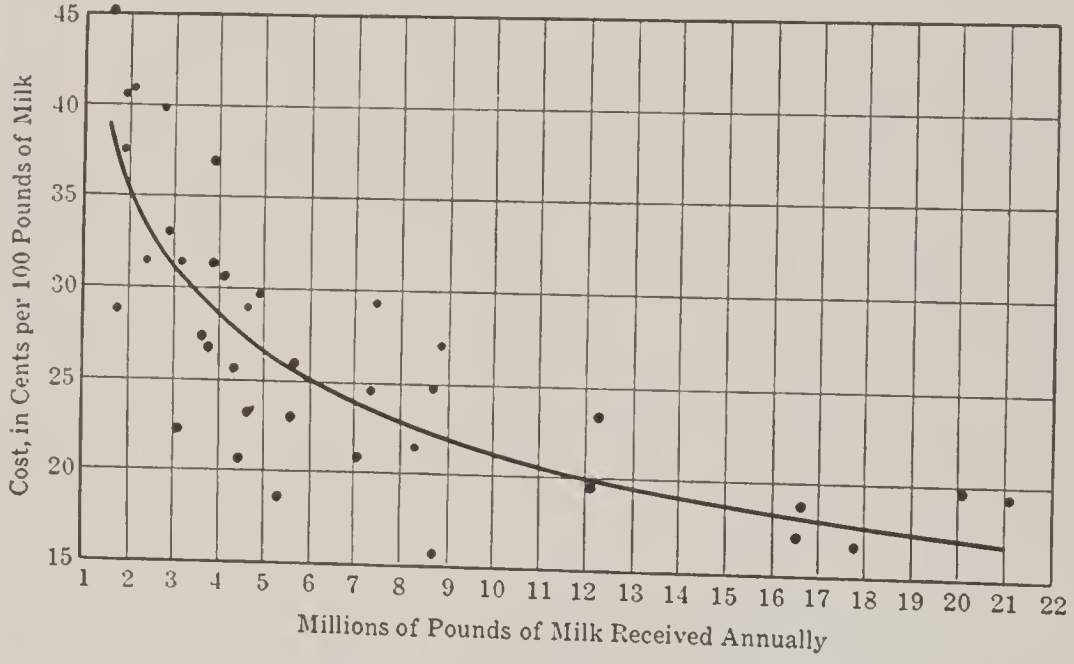

Cost, in Cents per 100 Pounds of Milk
45
40
35
30
25
20
15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Millions of Pounds of Milk Received Annually

Fig. 55.—Relation of volume of milk received per plant, to plant-operating cost, 38 country receiving plants.

The average cost of operation per hundred-weight for the total 13 plants was 22.64 cents.

The foregoing tables illustrate the important rôle that volume of milk handled plays in the per unit costs of operation.

In one city, receiving milk from 91 stations, the average quantity received daily per plant for a period of one year was 13,910 pounds, varying from 938 pounds at the smallest plant to 53,865 at the largest plant. It is apparent that at many of these plants the volume was too small for the most economical plant operation.

NUMBER OF MEN REQUIRED TO OPERATE COUNTRY RECEIVING STATIONS OF VARIOUS CAPACITIES

Table 60 shows the number of men employed at 72 country stations of various sizes from which the milk was shipped in cans; Table 61 shows the number of men employed at 121 plants of various sizes from which the milk was shipped in bulk in either tank trucks or tank cars. The average quantity of milk handled per man employed at the various sized plants is also shown.

TABLE 60

LABOR EMPLOYED AT 72 PLANTS FROM WHICH THE MILK WAS SHIPPED IN CANS

Size of Plant. Pounds of Milk Received Daily.	Number of Plants.	Average Pounds of Milk Received per Plant.	Number of Men per Plant.	Pounds of Milk Handled per Man.
5,000 or less.....	5	3,681	1.4	2,743
5,001 to 10,000...	11	6,886	2.7	2,992
10,001 to 15,000...	14	12,417	3.1	3,871
15,001 to 20,000...	22	17,621	4.0	4,563
20,001 to 30,000...	10	23,799	4.9	5,166
30,001 to 50,000...	7	36,129	6.1	6,253
Over 50,000.....	3	58,700	10.0	6,055

It will be noted that at both types of plants a greater quantity of milk is handled per man employed as the size of the plant increases. The tables clearly illustrate the importance of volume of milk handled in its effect on economy in the use of labor in the plant.

It will also be noted that fewer men are used per plant of similar capacity and more milk is handled per man employed at the plants from which the milk is shipped in bulk than at those plants where cans are used.

When the milk is shipped in bulk no cans are required, and the milk is pumped from the cooler to the storage tanks or directly to the tank car or tank truck. Where cans are used, much extra labor is required to wash the cans, draw the milk off into them, and load the cans of milk on the car or truck.

TABLE 61

LABOR EMPLOYED AT 121 PLANTS FROM WHICH THE MILK WAS SHIPPED IN TANKS

Size of Plant. Pounds of Milk Received Daily.	Number of Plants.	Average Pounds of Milk Received per Plant.	Number of Men per Plant.	Pounds of Milk Handled per Man.
5,000 or less.....	5	3,580	1.0	3,580
5,001 to 10,000...	33	7,874	1.2	7,000
10,001 to 15,000...	21	12,609	1.3	10,417
15,001 to 20,000...	18	16,566	1.6	12,186
20,001 to 30,000...	20	24,472	2.5	10,149
30,001 to 50,000...	13	40,400	3.9	11,825
Over 50,000.....	11	72,273	4.9	15,701

RELATION OF VOLUME OF MILK HANDLED TO INVESTMENTS IN PLANTS

Table 62 shows the investments in buildings, and equipment at 75 plants of various sizes from which the milk was shipped to the

TABLE 62

RELATION OF VOLUME TO INVESTMENTS IN BUILDINGS, AND EQUIPMENT AT 75 COUNTRY RECEIVING STATIONS FROM WHICH THE MILK IS SHIPPED IN CANS.

Size of Plant. Pounds of Milk Received Daily.	Number of Plants.	Average Quantity Received Daily. Pounds.	Average Investment in Buildings.		Average Investment in Equipment.	
			Per Plant. Dollars.	Per Cwt. Dollars.	Per Plant. Dollars.	Per Cwt. Dollars.
Less than 5,000	7	3,703	6,917.49‡	180.45	2,776.25	74.98
5,001 to 8,000.	16	6,282	8,925.61§	144.64	5,300.64	81.86
8,001 to 10,000	10	9,239	7,085.10	76.68	5,931.98	64.73
10,001 to 15,000	18	12,016	9,632.56	80.16	6,319.06§	52.28
15,001 to 20,000	11	17,746*	14,379.32	81.03	11,643.05	66.73
20,001 to 30,000	5	24,652†	17,216.79	69.82	10,133.95	41.11
Over 30,000....	8	38,456	22,082.73	57.43	21,369.91†	54.50

* 8 plants. † 3 plants. ‡ 6 plants. § 16 plants.

market in cans. As the size of the plant increases more investment in building and equipment is required. The table shows, however, that the investment per 100 pounds handled is greater at the plants of the smaller capacities. These large per unit investments at the smaller

plants naturally result in higher cost of operation per hundred-weight handled.

Table 63 shows the investments in land, buildings, and equipment at 57 plants from which the milk was shipped to the city in tank trucks or

TABLE 63

Relation of Volume to Investments in Land, Buildings, and Equipment at 57 Country Receiving Stations from which the Milk Is Shipped in Tank Cars or Tank Trucks

Size of Plant. Pounds of Milk Received Daily.	Number of Plants.	Average Quantity Received Daily. Pounds.	Average Investment in Land.		Average Investment in Buildings.		Average Investment in Equipment.	
			Per Plant. Dollars.	Per Cwt. Dollars.	Per Plant. Dollars.	Per Cwt. Dollars.	Per Plant. Dollars.	Per Cwt. Dollars.
5,000 to 8,000.	4	6,247	867.26	14.51	3,926.18	63.80	4,799.82	76.76
8,001 to 10,000	8	8,530	726.47	8.62	2,944.41	34.93*	4,340.87	44.55*
10,001 to 15,000	7	12,914	.....	.....	.....	.....	7,731.79	59.87
15,001 to 20,000	12	17,290	699.64	3.86	7,490.90	42.96	9,150.94	52.92
20,001 to 30,000	11	25,411	1,427.55	5.59	8,171.02	31.99	12,070.01	47.86
30,001 to 50,000	11	41,204	2,566.19	6.23	21,869.79	53.08	22,217.29	53.92
Over 50,000....	4	60,848	3,968.34	6.52	29,052.78	47.74	20,222.97	33.23

* Most of the plants in this group consisted of frame buildings and very simple equipment.

TABLE 64

Relation of Volume to Investments in Land, Buildings, and Equipment at 13 Country Receiving Stations in Vermont (2)

Volume of Milk Received Annually. Pounds.	Number of Stations.	Investments on Land and Buildings.		Investments in Equipment.	
		Per Plant. Dollars.	Per Cwt. Handled Annually. Cents.	Per Plant. Dollars.	Per Cwt. Handled Annually. Cents.
4,229,000..	4	9,076.02	20.99	6,686.25	16.02
5,934,000..	5	12,701.85	20.69	5,181.60	7.02
10,873,000..	4	19,160.30	17.34	12,137.25	10.96
Av. 6,929,000..	.....	13,573.42	19.75	7,784.31	10.98

tank cars. As a rule, the investment is less than at the plants of similar capacities which ship in cans. Several plants in the group handling from 30,001 to 50,000 pounds daily were of stone, reinforced

TABLE 65

RELATION OF VOLUME OF MILK TO INVESTMENTS IN LAND, BUILDINGS, AND EQUIPMENT AT 29 COUNTRY RECEIVING STATIONS IN NEW YORK STATE (1)

Volume of Milk Received Annually. Pounds.	Number of Plants.	Average Volume.		Average Investment per Plant.				Average Investments per 100 Pounds of Milk.			
		Pounds per Year.	Cans per Day.	Land. Dollars.	Buildings. Dollars.	Equipment. Dollars.	Total. Dollars.	Land. Cents.	Buildings. Cents.	Equipment. Cents.	Total. Cents.
Less than 4,000,000.....	11	2,923,183	93	928.45	13,087.78	6,756.56	20,772.79	3.2	44.8	23.1	71.1
4,000,000 to 8,000,000.....	9	5,492,702	175	876.82	17,603.83	7,841.31	26,321.96	1.6	32.0	14.3	47.9
More than 8,000,000.....	9	13,063,113	416	1,709.89	23,503.04	22,632.75	47,845.68	1.3	18.0	17.3	36.6

concrete, or brick construction and were especially well equipped with modern machinery, as a result of which the investment per 100 pounds handled was relatively high. The unit cost of operation of these plants, however, was comparatively low.

Table 64 shows the relation of the volume of milk handled to the investments in land, buildings, and equipment at 13 stations in Vermont. (2)

Table 65 shows the investments in land, buildings, and equipment at 29 milk-receiving stations from which the milk was shipped to New York City.(1)

The foregoing tables show that the investments required per hundred-weight handled are as a rule greater at the plants with the smaller volume of milk, and they further illustrate the fact that plants with a large volume are more economical than the plants with a small volume.

REFERENCES

(1) Tucker, C. K., The Cost of Handling Fluid Milk and Cream in Country Plants. Cornell University Agri. Exp. Sta., Ithaca, N. Y., Bul. 473, 1929.

(2) Camburn, O. M., Milk Receiving Station Operation in Vermont. Vermont Agri. Exp. Sta., Burlington, Vt., Bul. 303, 1929.

Stocking, W. A., Ayers, W. E., Potts, Roy C., and Meyer H. F., Country Milk Stations. Cornell Extension Bul. 30, 1918.

CHAPTER XVI

THE CITY MILK PLANT—CONSTRUCTION AND ARRANGEMENT

As was shown in Chapter XIV, the milk supply of the large cities is shipped for considerable distances to city milk dealers. These dealers bring the milk to their plants in the city where it is pasteurized and put into bottles, ready for delivery to the consumer. In order to pasteurize and prepare the milk for delivery to the consumer, the modern city milk plant has been developed.

The milk plant should be a modern, sanitary building, of durable construction and equipped with sanitary and up-to-date apparatus. It must be so arranged that the milk can be received and handled efficiently and economically, and proper facilities must be provided for receiving, weighing and sampling the milk. From the receiving tank, the milk goes to the clarifying and pasteurizing apparatus, and thence to the bottle fillers and cappers. After the milk is put into the bottles and sealed, it must be kept in a cold place until it is sent out on the delivery wagons. Facilities must also be provided for washing the cans and the bottles. In general, the milk plant should be modern in every way, and should be of good appearance from an architectural point of view.

CITY MILK PLANTS NOW IN EXISTENCE

At present there is no standard type of city milk plant, many of the plants being old wooden buildings, which were formerly used for other purposes, and which have been used by the milk dealer when his business was small and very little equipment was required. As his business grew, he would make additions from time to time, to make room for more equipment, with the result that the plant has no systematic plan or arrangement. Some plants consist of a back room in the dwelling house; the opposite extreme is the modern city milk plant, built of concrete or brick, often costing large sums of money and provided with the latest and most sanitary type of equipment.

LOCATION OF PLANT

The following are the principal points to consider in locating the milk plant:

1. Ease of access from as many sides as possible.
2. Value of property.
3. Cost of getting the milk to the plant.
4. Proximity to distribution center.
5. Advertising possibilities.
6. Opportunity for retail counter cash trade.
7. Convenience to city water supply and electric power.
8. Avoidance of heavy traffic surroundings.
9. Good drainage.
10. Pure air and clean surroundings.

FIG. 55*a*.—A modern city milk plant.

It is desirable to have the plant located so that it can be approached from two sides in addition to the front. Milk and bottles may then be taken in at one side of the building, while the delivery wagons may be loaded at the other side of the building, and there will be no confusion or congestion.

Whether to erect the plant on an expensive site in the business section of the city or to go further out on less expensive property, is an important question. An attractive plant located in the downtown section of the city will not only be a good advertising feature, but will often result in a large quantity of cash sales at the plant. However, unless competition is an important factor, it would not be advisable to buy a very expensive site for the plant.

Whether to locate the plant near the railroad or nearer the distribution center must also be decided. In recent years many milk-distributing companies have increased greatly in size and have therefore established branch distributing plants. The milk is bottled at the main plant and transported by truck to the branch plants, from which the routes receive their loads. These branch plants are of course located in

the distributing area. When branch plants are operated in this way, the question of receiving the milk from the country is of great importance in regard to location of the main pasteurizing plant. With the advent of tank-car transportation the tendency has been in recent years for large companies to locate the main plant on the railroad so that the tank car can be transferred to the plant and the milk received from it direct.

CLASSES AND TYPES OF PLANTS

There are various ways in which plants may be classified. They may be divided into the the following seven classes, the basis of classification being the method of handling the milk in the plant:

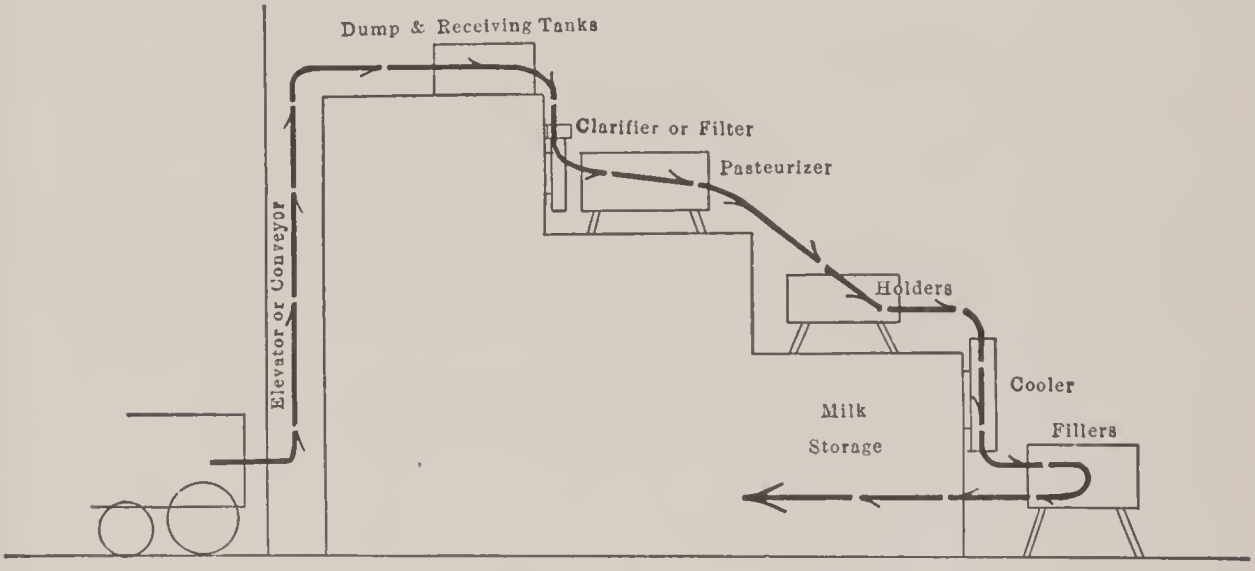


FIG. 56.—Course of milk at plant of Class 1 type.

1. *Gravity, More than One Story.*—In this class of plants the milk in cans is elevated above the first floor and dumped. It then flows by

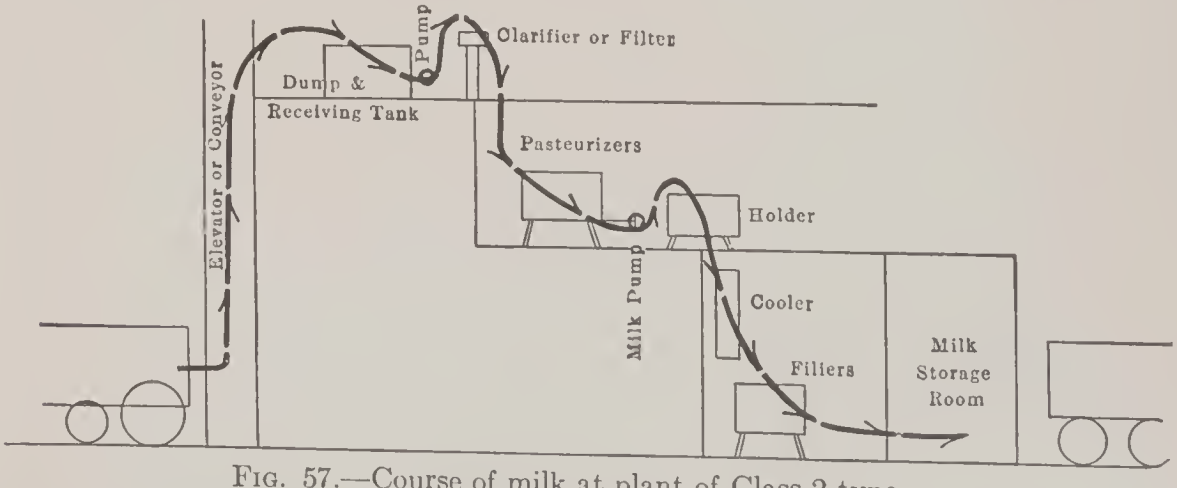


FIG. 57.—Course of milk at plant of Class 2 type.

gravity through pasteurizing and other machinery without the use of a milk pump.

2. *Gravity and Pump, More than One Story.*—Milk is elevated in cans above the first floor, and dumped. It flows by gravity through part of the machinery, but pumps are also used before it reaches the filler.

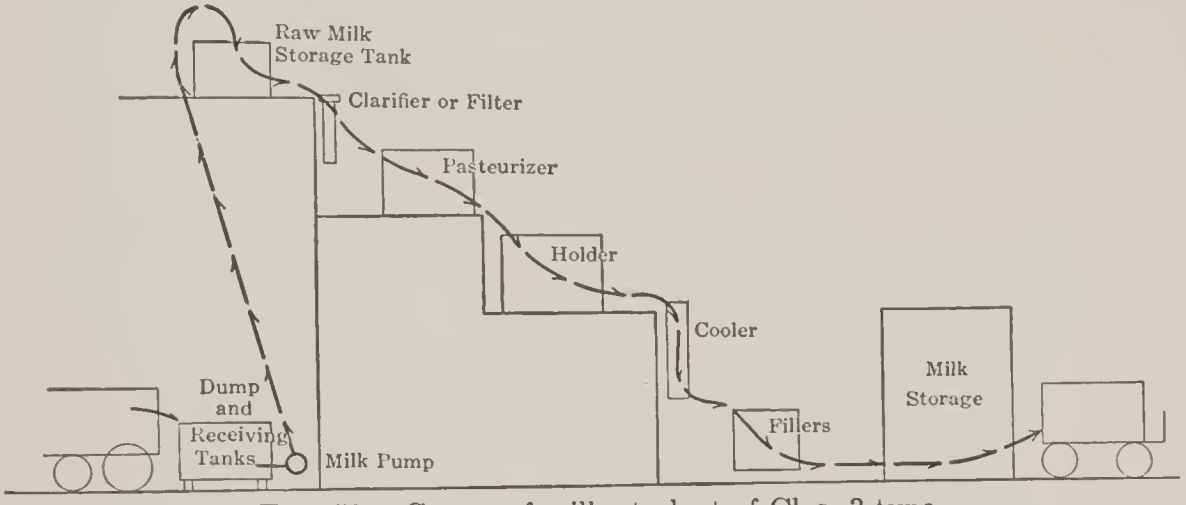


FIG. 58.—Course of milk at plant of Class 3 type.

3. *Pump to Higher Level, then Gravity.*—The milk is dumped into a tank on the first floor and pumped to a floor above, whence it flows through the various pieces of apparatus by gravity, without the further use of a milk pump.

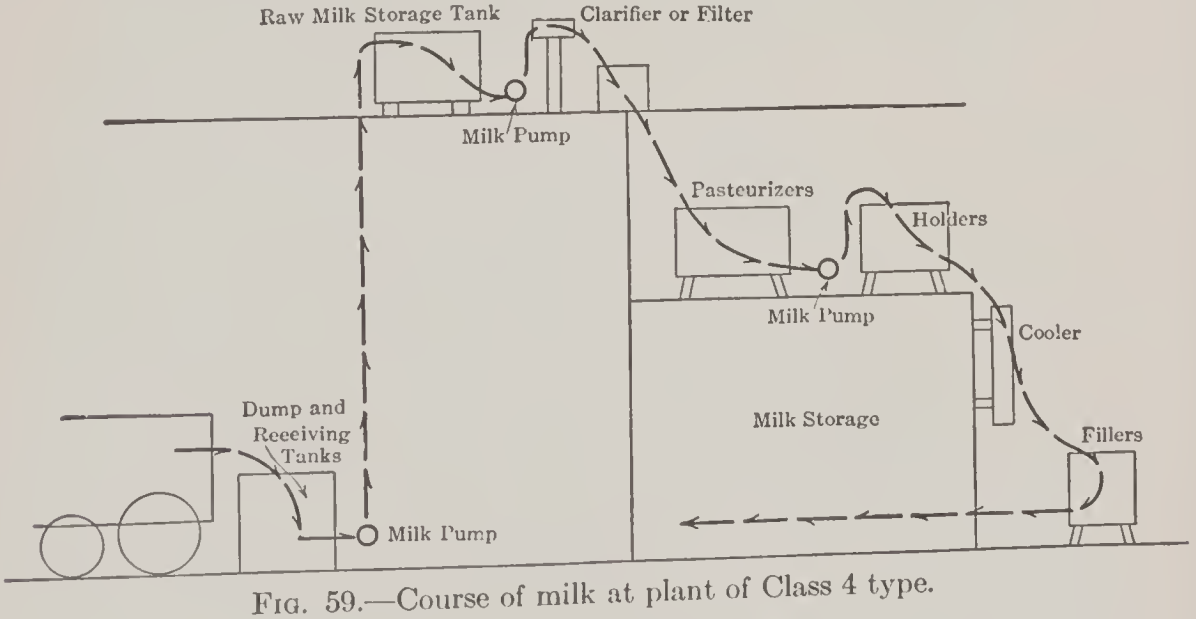


FIG. 59.—Course of milk at plant of Class 4 type.

4. *Pump to Higher Level, then Gravity and Pump.*—The milk is pumped from the first to a floor above. From that point it is handled by pumps, or partly by pumps and partly by gravity.

5. Same as Class 4, except that the bottle fillers are on the second floor instead of the ground floor. The filled bottles are conveyed from the second floor to the milk-storage room on the ground floor by power or gravity conveyors.

6. *Pump, One Story.*—The milk is handled on one floor, one or more pumps being used.

7. Milk sent to raw-milk storage tanks below the ground floor level, whence it is pumped to a higher floor level, with gravity, or pumps and gravity, used from that point, as in Classes 3, 4, and 5.

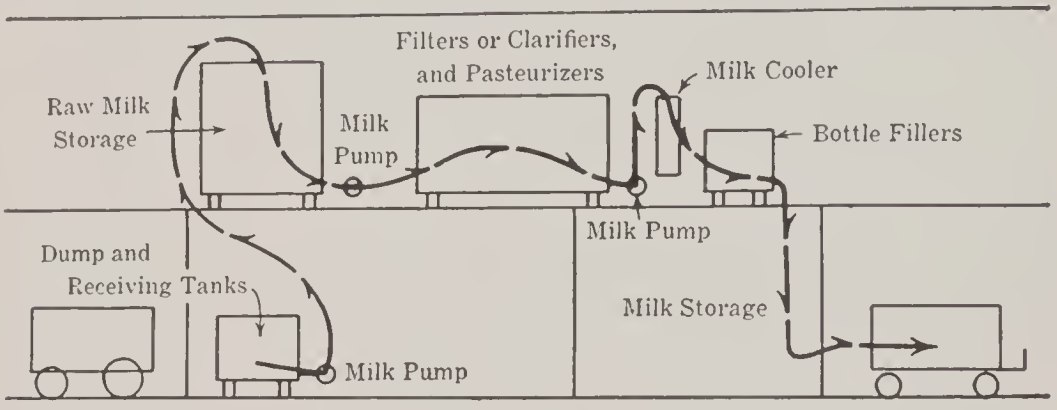


FIG. 60.—Course of milk at plant of Class 5 type.

In a survey of 336 milk plants made by the Bureau of Dairy Industry, plants of various capacities fell into the various classes as indicated in Table 66.

TABLE 66

CITY MILK PLANTS CLASSIFIED AS TO COURSE OF MILK THROUGH PLANT (2)

Size of Plant. Gallons of Milk Handled Daily.	Number of Plants in Class.							Total.
	1	2	3	4	5	6	7	
100 or less	0	0	0	0	0	11	0	11
101 to 250	1	0	0	0	0	37	0	38
251 to 500	0	0	6	1	0	24	0	31
501 to 1,000	0	0	6	2	0	23	0	31
1,000 to 2,000	0	1	5	3	0	28	0	37
2,001 to 3,000	0	0	1	7	0	7	0	15
3,001 to 5,000	1	3	1	17	0	17	0	39
5,000 to 10,000	1	2	2	47	7	6	0	65
10,000 to 15,000	0	2	1	18	3	1	0	25
15,000 to 20,000	0	1	0	11	3	0	0	15
20,001 to 30,000	0	1	0	9	6	1	0	17
Over 30,000	0	1	1	3	3	2	2	12
Total	3	11	23	118	22	157	2	336

It will be noted that plants in Classes 1 and 2 are not common; in this survey there were only 14 such plants in these two classes. It is

generally considered more economical and satisfactory to pump the milk as it is received, than to elevate in cans by means of elevators or

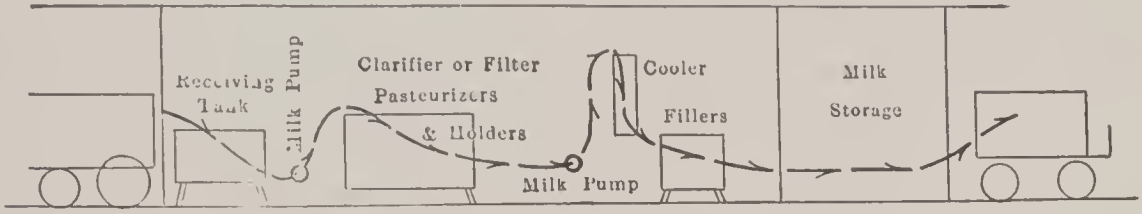


FIG. 61.—Course of milk at plant of Class 6 type.

escalators. If the pump is of proper design and is kept clean, there is no objection to pumping the cold raw milk from the receiving tank to the raw-milk storage tanks or the pasteurizing department. Also, pumping the cold raw milk to the preheater or the clarifier and pumping the hot pasteurized milk over the cooler under the same conditions are not considered injurious to the milk. There are only a few plants in Class 3, but there is a large number in Class 4.

The type of plant represented by Class 6 was most commonly found, although most of the larger plants were in Class 4.

The placing of the raw-milk storage tanks below the ground level (as in Class 7) is a comparatively new idea in milk plants, but this system seems to have certain advantages, especially where the milk is received in tank cars or trucks. The milk flows by gravity to these tanks from the receiving room, and when it is received in tank cars or trucks these can be unloaded very rapidly with this system. Furthermore, space is saved in other parts of the plant.

Plants may be classified also on the basis of the course of the bottles through the plant, into the following five classes:

A. All operations on first floor.

B. Bottles washed in the basement, with all the other operations on the first floor.

C. Bottles washed and filled on the second floor, with milk-storage room on the first floor.

D. All operations on the first floor, except that the empty bottles are stored on an upper floor level or in the basement.

E. Bottles washed in the basement, with fillers above the first floor level and milk-storage room on the first floor.

In a survey of 289 city milk plants made by the Bureau of Dairy Industry, plants of various capacities fell into these five classes as indicated in Table 67.

It will be noted that 241 of these plants are of the type represented by Class *A*. This is 83 per cent of the total. As indicated elsewhere, both the labor requirements and bottle breakage are less where the

TABLE 67

CITY MILK PLANTS CLASSIFIED AS TO COURSE OF BOTTLES THROUGH PLANT (2)

Size of Plant. Gallons of Milk Handled Daily.	Number of Plants in Class.					Total.
	A	*B*	*C*	*D*	*E*	
500 or less	80	0	0	0	0	80
501 to 1,000	25	0	0	0	0	25
1,001 to 2,000	26	0	0	0	0	26
2,001 to 3,000	8*	1	0	0	1§	10
3,001 to 5,000	27	1	1	1	0	30
5,001 to 10,000	43	5	6	1	1	56
10,001 to 15,000	14	3	2	2†	0	21
15,001 to 20,000	8	1	4	2	0	15
20,001 to 30,000	7*	3	5	2‡	0	17
Over 30,000	3	2	1	2†	1	9
Total	241	16	19	10	3	289

* At one plant the milk-storage room was in the basement.
† At one plant the bottles were stored in the basement.
‡ At both plants the bottles were stored in the basement.
§ Bottles were stored above the first floor after washing, but were filled on street floor.

bottle-washing and filling departments and the milk-storage room are all on the first floor. In this type of plant less transferring of the bottles, which tends to cause breakage, is necessary than in plants where the operations are on different floor levels; also, fewer foremen are needed to operate the plant.

At plants of the type represented by Class *B*, the results in regard to economy of labor and bottle breakage are practically as good as at the plants of the type in Class *A*, if proper conveying systems are used to get the bottles to the washers in the basement and if the bottles, after being washed, are elevated to the first floor by the washer itself. Plants of the types represented by Classes *C*, *D*, and *E* are not common, and are usually found where it is necessary to economize in ground area.

NUMBER OF FLOORS IN MILK PLANTS

In the construction of milk plants the tendency in recent years has been to build plants of only one or two stories. In a recent survey (2) of 307 plants only 77 were of more than two stories. The 307 plants included 66 plants handling less than 1000 gallons daily. Of these 66 plants, 40 plants, or about 61 per cent, were one-story plants.

Table 68 shows the number of stories at 307 plants of various capacities.

TABLE 68

NUMBER OF STORIES IN 307 CITY MILK PLANTS (1930). (2)

Gallons of Milk.	Number of Plants in Group.	Number of 1-story Plants.	Number of 2-story Plants.	Number of 3-story Plants.	Number of Plants Having More than 3 Stories.
500 or less	32	23	8	1	0
501 to 1,000	34	17	15	1	1
1,001 to 2,000	44	15	24	4	1
2,001 to 3,000	36	7	22	6	1
3,001 to 5,000	46	14	22	7	3
5,001 to 10,000	60	16	27	15	2
10,001 to 20,000	31	4	10	15	2
Over 20,000	24	2	4	13	5
Total	307	98	132	62	15

Although many of the larger plants have more than one floor level, there is also a tendency in constructing large plants to confine them to only one or two stories. In the present survey there were 161 plants handling more than 3000 gallons daily, and 99 of these, or 61 per cent, were of only one or two stories. At a very large percentage of all the plants included in the survey, the bottle-washing and filling departments and the milk-storage room were all on the ground-floor level. As indicated elsewhere, both the cost of labor for plant operation and the losses from breakage of bottles in the plant tend to be less for those plants where all of these departments are on the first floor. At plants with basements where the bottles are washed in the basement and are mechanically delivered to the ground floor by the washer itself, practically as good results are obtained with regard to cost of labor and to losses from bottle breakage as at the plants where the bottles are washed on the first floor, provided that, in the former case, proper conveying systems are used to transfer the bottles to the washers in the basement.

Of course, where a plant is to be located on an expensive site it is usually desirable to have more than two stories, but where a building site of ample space is available at moderate cost, the plant of one or two stories seems to have many advantages.

RELATION BETWEEN NUMBER OF STORIES IN PLANT AND LABOR REQUIREMENTS

The number of men required to operate a milk plant seems to be affected to some extent at least by the number of stories in the plant. As a rule, fewer men are required in plants using only one story than in plants using several stories.

Table 69 shows the relation between the number of stories in the plant and the labor requirements.

TABLE 69

RELATION BETWEEN THE NUMBER OF STORIES AND LABOR REQUIREMENTS IN MILK PLANTS (3)

Plants Having One Story

Group.	Plants.	Milk and Cream Handled per Plant.			Employees.	Milk and Cream Handled per Employee.		
		Quantity.	Average.	Bottled.		Total.	Bottled.	Exclusive of Checkers.*
	Number.	Gallons.	Gallons.	Per Cent.	Number.	Gallons.	Gallons.	Gallons.
1	5	2,000 or less.....	1,314	83.7	5.8	227	190	263
2	10	2,001 to 5,000...	3,152	88.9	11.0	287	255	341
3	6	5,001 to 10,000..	7,570	90.1	26.2	289	261	361
4	2	10,001 to 15,000..	10,975	84.5	30.0	366	309	422
5	.....	15,001 to 20,000..	.....	.....	.....	.....	.....	.....
6	1	Over 20,000.....	21,000	82.0	67.0	313	257	344

Plants Having Two Stories

1	8	2,000 or less.....	1,466	79.6	7.4	199	158	228
2	11	2,001 to 5,000...	3,631	85.7	19.0	189	164	220
3	23	5,001 to 10,000..	7,103	84.9	34.4	206	175	252
4	6	10,001 to 15,000..	11,742	80.6	52.5	224	180	263
5	4	15,001 to 20,000..	16,875	83.7	57.3	295	247	343
6	3	Over 20,000.....	25,261	88.1	102.6	246	217	277

Plants Having Three or More Stories

1	.....	2,000 or less.....	.....	.....	.....	.....	.....	.....
2	.....	2,001 to 5,000...	.....	.....	.....	.....	.....	.....
3	5	5,001 to 10,000..	8,169	82.7	45.0	182	150	235
4	1	10,001 to 15,000..	11,150	88.0	41.0	272	239	372
5	4	15,001 to 20,000..	17,910	89.3	100.0	179	160	220
6	3	Over 20,000.....	31,783	89.3	115.3	276	246	327

* At some plants the checkers are not included with the plant employees but with the delivery or sales employees.

More milk was handled per plant employee in the one-story plants than in the two-story plants, and with only two exceptions more was handled in the two-story plants than in the plants of three or more stories. In Group 6 less milk was handled per man in the two-story plants than in the plants of three or more stories. One of the reasons for this was that one of the two-story plants was a grade A plant [1] and

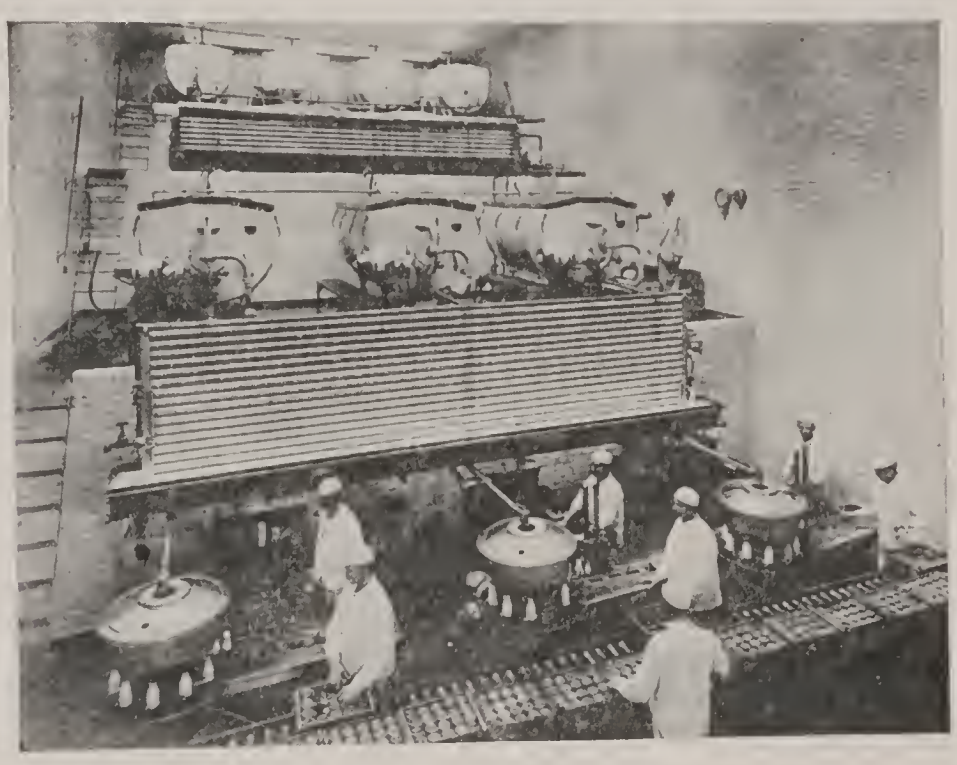


FIG. 62.—Interior of a modern city milk plant.

handled only 188 gallons of bottled milk per plant employee, which lowered the average for the group. The other exception was the one plant of three or more stories in Group 4. In this plant the milk was pasteurized on the second floor and was bottled on the first floor. The bottles were washed in the basement, but the bottle washer elevated the bottles to the first floor, where they were filled, thus eliminating the necessity of conveyors or elevators.

From the survey that was made it seems apparent that best results as to labor required are obtained where the bottle-washing and filling departments and the milk-storage room are on the street floor. The principal reason for this is that a minimum of handling and of supervision is required at this type of plant. Where the bottles are washed in the basement and the bottle washer delivers the bottles to the fillers on the street floor, nearly as good results are achieved.

[1] This plant, because it handled grade A milk, met special requirements of the City health officials.

CONSTRUCTION OF PLANT

Material.—The kind of material best adapted to the construction of the milk plant will depend a good deal on local conditions. The durability and cost of the material should be first considered. Frame buildings were formerly quite popular, but in recent years milk plants

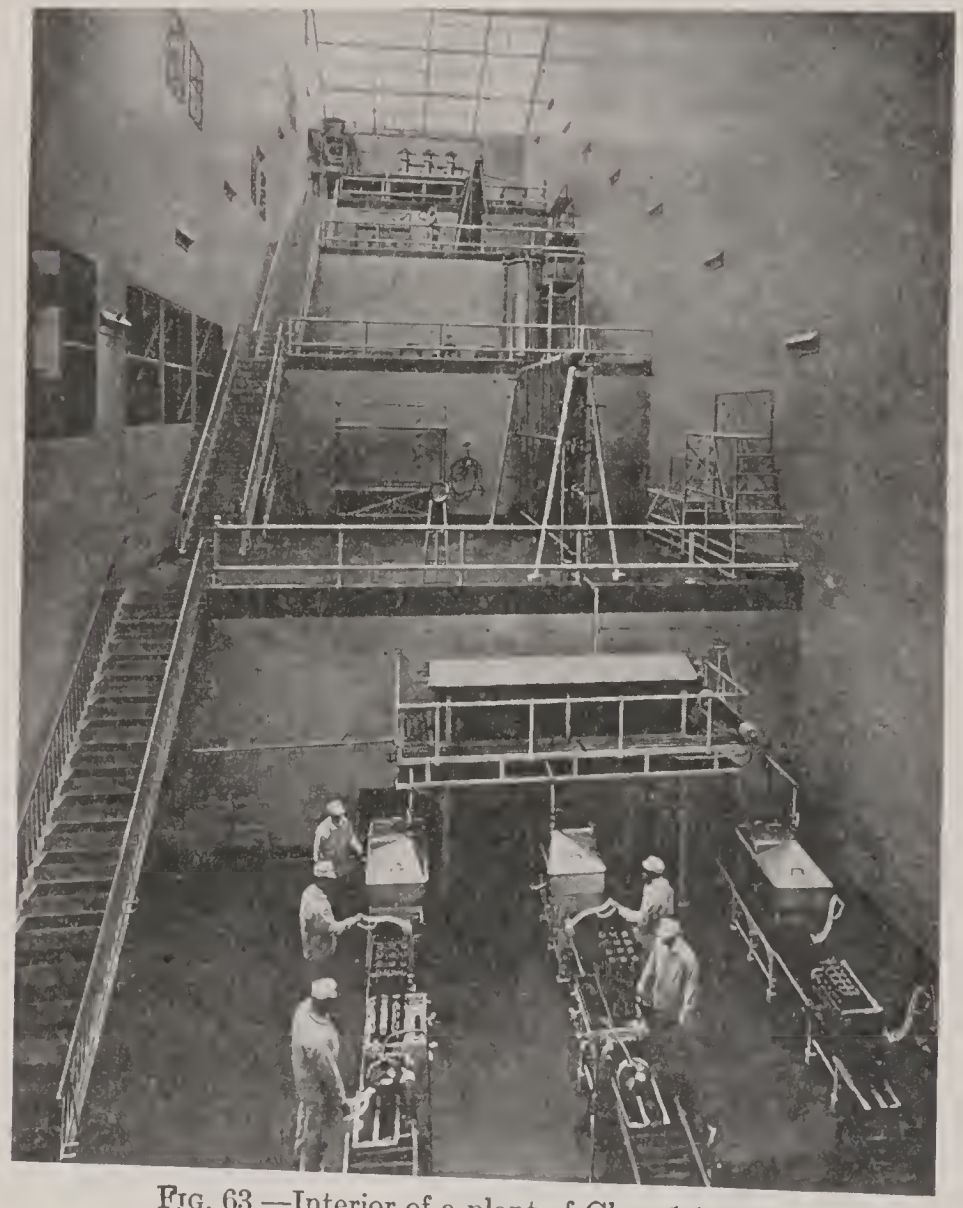


FIG. 63.—Interior of a plant of Class 1 type.

have generally been constructed of a more permanent material, some of the more satisfactory materials being concrete, hollow tile and brick. Buildings of these materials are more durable than those of wood, and the cost of repairs and upkeep is less; such materials are also practically fireproof. Where hollow tile is used, it should be finished with stucco on the outside and with smooth cement on the inside. The roofing material should be fireproof.

Inside Walls and Ceilings.—The inside walls should be of a material that is smooth, easily cleaned, durable and waterproof. Cement, coated with a paint that is as nearly waterproof and steamproof as possible, is satisfactory. For the more important rooms, where the milk is handled, tile or enamel brick may be used. While these materials are expensive they will add greatly to the appearance and sanitation of the rooms. The ceilings as well as the inside walls should be of a material that is smooth, durable and easily cleaned.

Floor Construction.—Floors should be of tile or cement with a waterproof coating, and special attention should be given to the proper laying of them. It is important that there should be a good foundation, and all drain pipes should be in place before the floors are laid. The floors should slope about $\frac{1}{4}$ inch per foot to the floor drains, and the drains should be trapped and connected to the sewer. The milk-handling rooms may have tile floors, which, though more expensive, will add to the appearance. Iron grids or plates imbedded in the cement will prolong the life of floors in rooms where cans and trucks are constantly handled.

Ventilation.—Proper ventilation in the milk plant is important, both from the standpoint of the sanitary condition of the milk and that of the health of the employees. Various methods of ventilation are used, such as ventilating drafts, flues, etc. In large plants the air is often forced through a filter to purify it, and in some modern plants it is passed through sprays of water. By heating or cooling the spray of water, the temperature in the rooms may be controlled to a certain extent. The air is forced, by means of fans, through the filter or spray of water and through flues into the rooms, and the foul air passes out through other flues or through small openings in the roof of the building.

Light.—The milk plant, especially in rooms where the milk is handled, should be well lighted, and plenty of window space should be provided. Plenty of light tends to promote cleanliness and sanitation in the plant. In the score card for the sanitary inspection of city milk plants, used by the Bureau of Dairy Industry, Department of Agriculture, two points are given for sufficient light, and it is recommended that the window space be 10 per cent of the floor area.

ARRANGEMENT OF MILK PLANT

In the arrangement of the plant, economy of operation, as well as sanitation, must be considered. Provision must be made for the convenient and rapid receiving of the milk as it arrives on the trucks, and for this purpose a platform on the exterior of the building has been found to be advantageous. The milk is unloaded from the trucks and

put on the platform, from which it goes to the receiving room. If the receiving room is a considerable distance from the receiving platform, power or gravity conveyors will be of great assistance. The floor of the platform should be on a level with the floor of an ordinary truck, so that the milk may be unloaded from the trucks without unnecessary lifting.

Milk Pumps Compared with Elevators.—Very few plants elevate the milk to the top floor in the cans, the majority using pumps. Studies were made by the Dairy Division of the U. S. Department of Agriculture, at twenty-eight typical plants, to determine the relative economy of the systems of (A) dumping the milk in tanks on the ground floor and

FIG. 64.—Conveyor used in plants of Class 1 type to elevate the milk.

then pumping from this tank to the receiving tank above, (B) raising the milk in cans to the top floor by means of power conveyors, and (C) raising the cans of milk by means of freight elevators. A comparison of the economy of the three systems is shown in Table 49. (1)

"From the data in this table it is apparent that the system of pumping the milk from the ground floor rather than elevating it in cans is much more economical in the use of labor. At these plants the pumping system was more than twice as efficient as the elevator and much more efficient than the conveyor system. The conveyor system, however, is more economical in the use of labor than the elevator system, and requires only about one-half as many man-hours to handle 100 cans of

milk. Of course, other factors enter into this problem, but these figures will illustrate the general tendency.

TABLE 70

COMPARISON OF MEN AND TIME REQUIRED TO RECEIVE AND DUMP THE MILK AND WASH THE CANS AT THREE DIFFERENT TYPES OF PLANTS (1)

Type of Plant.	Number of Plants.	Average Cans of Milk per Plant.	Average Time Spent per Plant. Hours.	Average Number of Men per Plant.	Average Hours of Labor per Plant.	Average Hours of Labor per 100 Cans Received.	Average Time per 100 Cans Received. Hours.	Average Cans Received and Dumped per hr.
A (pump)	18	1034.7	4.9	4.3	26.2	2.5	0.47	212.6
B (conveyor)	6	815	4.9	5.7	30.8	3.6	.58	172.0
C (elevator)	4	825	8.1	5.8	58.4	7.1	.99	101.5

FIG. 65.—Receiving milk and washing cans in plant of Class 1 type.

"In some plants it may be necessary to have the receiving room on the top floor, because of lack of space on the ground floor, but that is an arrangement to be avoided. Of course, in plants where the number of cans handled is small, the element of time spent in receiving the milk is of less importance, and conveyors, or even elevators, are often satisfactory." (1)

RECEIVING THE MILK

It is desirable to have the plant so arranged that the milk can be received with as small a labor cost as possible. A rapid system is also desirable so that the milk may be handled as fast as it arrives.

In many plants the cans of milk are transported by automobile or by horse-drawn trucks from the country or from the railroad station in the city to the receiving platform. From a study carried on at 63 milk plants, the following systems for receiving milk thus transported have been found: (3)

1. Cans are transferred from receiving-room door to weigh or dump tank by means of platform trucks. After being emptied and washed, they are returned by the same trucks to the loading-out door.
2. Cans are taken to the second or third floor by means of the ordinary freight elevator, which accommodates about 16 cans to the load. The empty cans, after being washed, are returned by the same elevator.
3. Cans are rolled from receiving-room door to the dump or weigh tank. This distance varies from 10 to 30 feet, but at the majority of the plants the distance is approximately 15 feet. In most cases the cans are fed directly into the washer by the man who empties the milk from the cans, although at a few of the plants another man is required to transfer the cans to the washer. At some of the plants the washer delivers the cans at a point near the door, whereas at others extra handling of cans is required at this point because of considerable distance from the delivery end of the washer to the point where they are loaded on the truck.
4. Dump or weigh tank is located close to the receiving-room door so that the cans are emptied with practically no handling. The washer is so located that the cans are transferred to it and out to the truck with little handling, but usually some handling is required either before or after the cans are washed. Some of the plants are so arranged that the man who empties the cans places them in the washer; whereas other plants have a space of 10 to 25 feet between the dump tank and the washer, in which case the washer usually leads directly to the loading-out door.
5. Cans are rolled approximately 12 feet from the receiving-room door to the dump tank, and after being emptied they are placed in an automatic washer from which they are transferred to the trucks by a gravity or power conveyor.
6. Cans are transferred from the receiving-room door to the dump or weigh tank by means of gravity or power conveyors. The cans are placed in the washer directly after being dumped, usually by the same man who empties them, there being no extra handling at this point. The washer leads to the loading-out door either directly or by means of conveyors so that there is no extra handling at this point.
7. Same system as 6 is used, except that the cans are elevated from the street floor to a higher level by means of power conveyors or lifts

and the washed cans are returned to the street floor by a similar conveyor or lift. When the cans of milk reach the higher floor they are conveyed to the dump tank as in system 6. The cans are placed directly in the washer, from which they pass on another conveyor to the lift or to a gravity conveyor which takes them to the street floor to be loaded on the trucks.

Comparison of Different Systems as to Time and Labor Required.—A comparison of the results obtained from the use of these systems at 63 milk plants showed that at the 23 plants using system 6 (Fig. 66) the number of gallons received per hour varied from 650 to 5685, and the number of gallons received per man-hour varied from

FIG. 66.—Receiving milk at a plant using system 6. At 23 plants using systems similar to this an average of 2334.4 gallons per hour and 459.6 gallons per man-hour was received. (3)

256.7 to 690.5, with averages of 2334.4 and 459.6 gallons, respectively. Seventy-four per cent of the milk received at the plants in this group was weighed, and 65 per cent of the plants weighed all the milk, which is a larger percentage than in most of the other groups of plants. This system is very efficient as to labor required and is desirable for either small or large plants, unless, in the case of small plants, system 4 can be used. With system 6 the milk was received and weighed very

rapidly with a small amount of labor. One plant with well-arranged conveyors received the milk at the rate of 708.8 cans per hour and 71.9 cans per man-hour.

Furthermore, system 6 is the most adaptable to plants having various arrangements of equipment. The plants using system 4 required the

FIG. 67.—Receiving milk at a plant using system 3. An average of 289.9 gallons per man-hour and 1079.6 gallons per hour was received at 20 plants using this system. (3)

least number of men, but these plants were smaller than most of the others studied. Systems 1, 2, and 3 were the lowest in average number of gallons handled per hour and per man-hour.

CHECKING IN THE ROUTES

The operation of verifying the driver's count of empty bottles and unsold goods and keeping the platform clear is called "checking in the routes." As a rule, the driver sets the bottles on the platform or on conveyors or trucks, if they are used; and the checker, after verifying the driver's count, transfers the bottles to another point. In some cases, however, he transfers the bottles from the platform to the conveyors or trucks. He also usually dumps or otherwise takes

care of the unsold goods which are returned. The time required for the latter work, however, is not included in the time required to check in the routes. From a study carried on at 82 plants, the following classifications have been made of the systems used in checking in routes: (3)

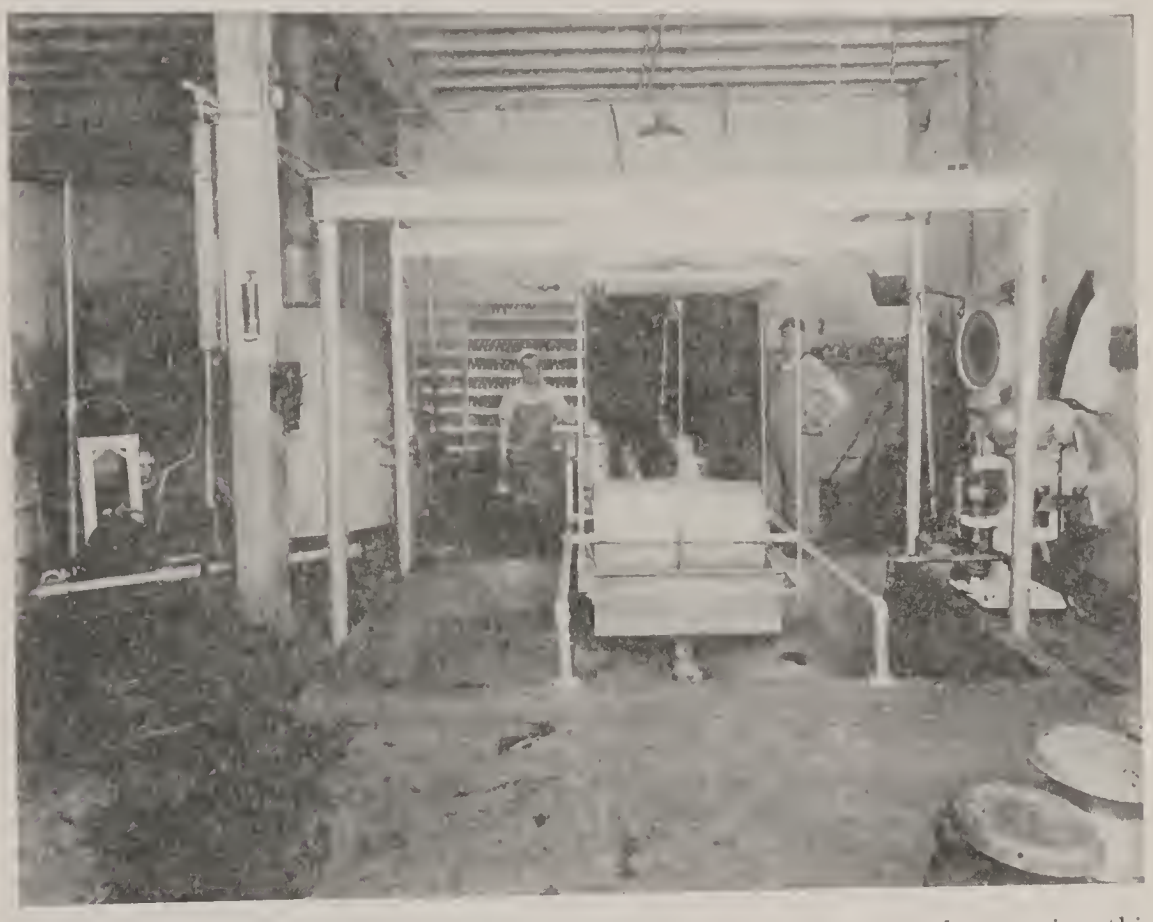


FIG. 68.—Receiving milk at a plant using system 4. At seven plants using this system an average of 1506.1 gallons per hour and 613.4 gallons per man-hour was received. (3)

1. Bottles are checked in on a gravity conveyor which leads to the bottle-washing room or an adjoining storage room where they are stacked by the checkers. They are later removed from the stacks by the bottle-washing crew and transferred to the washer or to a conveyor leading to it. This system is used at plants where the bottles are not checked in and washed in one continuous operation.

2. Bottles are put on one or more conveyors by the drivers, and after the count has been verified they pass direct to the washers and are washed immediately. A small proportion of the bottles, however, must be stacked because the pints and quarts cannot be washed at the same time.

3. Bottles are put on one conveyor by the drivers, and after the count is verified they go direct to the washer. Many of the bottles, however, must be stacked because they come in too fast for the washer to handle, since in practically all the plants in this group only one bottle-washing

unit is used. Stacking is also necessary in most of the plants because pints and quarts cannot be washed at the same time.

4. Same as system 3 except that two or more conveyors are used. In some cases all the bottles from one wagon are unloaded at one conveyor, whereas in others pints are unloaded at one conveyor and quarts at another. In either case two or more routes may be checked in at the same time. The continuous or direct system of washing and filling is generally used.

5. Bottles are unloaded and checked on the receiving platform at three or more points. Quart bottles are usually checked in at one point, pints at another, unsold goods at another, and so on, the driver going from one point to the next and several routes being checked in at the same time.

6. Bottles are unloaded and checked on the platform close to the washer so that very little transferring is required. This system is adaptable only to small plants where the washer can be located in close proximity to the checking-in platform.

7. Bottles are unloaded and checked on the platform, and the stacks of bottles are dragged back with hooks or by hand by the checkers to the washing room or adjoining storage space. As this is a slow process, the routes cannot be checked in at a very rapid rate. Since the washing room is usually nearby, the distance that the stacks of bottles must be transferred is short.

8. Bottles are checked in and stacked on the platform and are then sent on conveyors to the washers by the checkers. At two of the three plants in this group the bottles were sent to another floor to be washed. At another plant they were checked in on a long platform at a considerable distance from the washing room. The two departments were so located, however, that the bottles could not pass in a straight line directly from the checking-in platform to the washer, as in the case of systems 2, 3, and 4. At this plant several routes could be checked in at the same time.

9. Bottles are checked in on the platform and transferred to the washing room or adjoining storage space by means of lift trucks, dolly trucks, or the ordinary three-wheel or four-wheel platform trucks. The lift trucks consist of platforms with skids under which a wheel truck is run; the platform is raised by the lever of the truck; and it, with the full load of bottles, is wheeled away to the washing or storage room. The dolly truck is a small truck with small wheels or castors. Four stacks of bottles can usually be piled on this truck, which is then pushed away by hand.

10. Bottles are checked in and stacked on the platform and transferred to the washing room or adjoining storage space by means of the ordinary barrel or warehouse truck, which usually carries six or seven cases to a load. This type of truck may have an attachment by means of which a man can readily transfer bottles stacked 10 cases high. At the particular plants studied, however, none of this latter type of trucks were in use. The bottles are usually checked in and stacked on a long platform, several routes often being checked in at the same time.

TABLE 71

COMPARISON OF THE RESULTS OBTAINED FROM THE USE OF 10 SYSTEMS OF CHECKING IN ROUTES AT 82 PLANTS (3)

System.	Plants. Number.	Routes per Plant.			Checking-in Requirements.			
		Wholesale. Number.	Retail. Number.	Total. Number.	Men. Number.	Hours. Number.	Man-hours. Number.	Per Route. Minutes.
2	8	2.1	71.1	73.2	2.8	3.2	9.0	2.7
6	7	.3	21.7	22.0	1.3	2.8	3.3	7.6
5	4	.....	152.3	152.3	7.0	3.8	27.0	1.5
3	18	5.0	57.9	62.9	2.5	4.3	11.4	4.5
7	11	2.5	30.0	32.5	1.9	2.9	6.3	5.3
4	5	8.6	93.2	101.8	5.8	4.2	25.4	2.5
1	12	4.8	58.5	63.3	3.4	4.8	16.7	5.2
9	10	7.0	39.4	46.4	3.2	4.6	12.8	5.9
10	4	18.0	46.0	64.0	3.0	6.6	20.2	6.2
8	3	10.3	60.7	71.0	5.0	5.2	25.5	4.4

System.	Routes Checked in per—		Man-hours Sorting and Getting Bottles to Washer.		Routes per Man-hour.† Number.	Time Required per 100 Routes for—	
	Hour. Number.	Man-hour. Number.	Number.	Per Cent.*		Checking in Alone. Man-hours.	Checking in Including Sorting and Getting Bottles to Washers. Man-hours.
2	22.5	8.1	9.1	50.3	4.1	12.4	24.4
6	7.9	6.7	1.4	29.8	4.7	14.9	21.3
5	40.6	5.6	27.6	50.5	2.8	17.9	35.7
3	14.5	5.5	11.1	49.3	2.8	18.2	35.7
7	11.4	5.2	5.8	47.9	2.7	19.2	37.0
4	24.5	4.0	19.8	43.8	2.3	25.0	43.5
1	11.5	3.8	14.8	47.0	2.0	26.3	50.0
9	10.1	3.6	16.2	55.9	1.6	27.8	62.5
10	9.7	3.2	22.9	53.1	1.5	31.3	66.7
8	13.7	2.8	27.7	52.1	1.3	35.7	76.9

* Per cent of total man-hours used for checking in, sorting, and getting bottles to washers.
† Including sorting and getting bottles to washers.

Comparison of Different Systems as to Time and Labor Required.—Table 71 shows the results of a study of the systems used in checking in routes at 82 plants. The table is arranged according to the efficiency of the systems in respect to the number of routes checked in per man-hour.

In the last column of this table are shown the total number of man-hours required to check in 100 routes, to sort the bottles, and to get

them to the washer. This is the most important column in the table by which to determine the most economical system of checking in

FIG. 69.—Unloading bottles on a conveyor at a plant using system 2. An average of 22.5 routes per hour and 8.1 routes per man-hour was checked in at eight plants using this system. (3)

routes as regards labor. In some plants the routes may be checked in at a low labor cost, but much additional labor may be required to

FIG. 70.—Checking in routes at a plant using system 5. An average of 40.6 routes was checked in per hour at four plants using this system. (3)

transfer the bottles from the checking-in platform to the bottle washers, in which case the system cannot be considered economical of labor.

FIG. 71.—A line of wagons waiting to be checked in at the plant shown in Fig. 70.

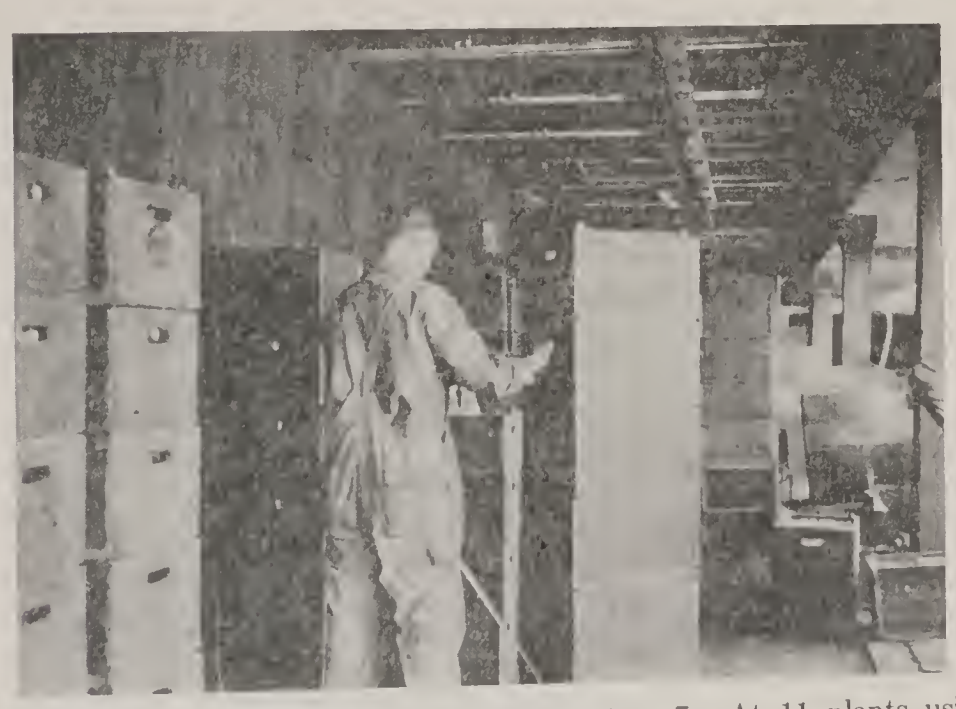


FIG. 72.—Checking in routes at plant using system 7. At 11 plants using this system an average of 11.4 routes was checked in per hour. (3)

Relation of Size of Plant to System Used.—It is desirable for plants of all sizes to employ a system by which all routes can be checked in in at least four or five hours. As a rule the large plants have adopted systems which are the most economical in the use of time. Fig. 73 shows the

relation of the size of plant to the system used at the plants studied. Dotted line *A–B* connects the blocks representing the average number of routes operated by the groups of plants using the various systems of checking in and dotted line *C–D* connects the blocks representing the average number of routes checked in per hour by these systems.

The lines are far apart for systems 8, 10, and 1, and they are very close together for systems 6 and 7. Systems 8, 10, and 1 are less efficient as to time required per route than would be expected from the number of routes at the plants in these groups. The use of system 8

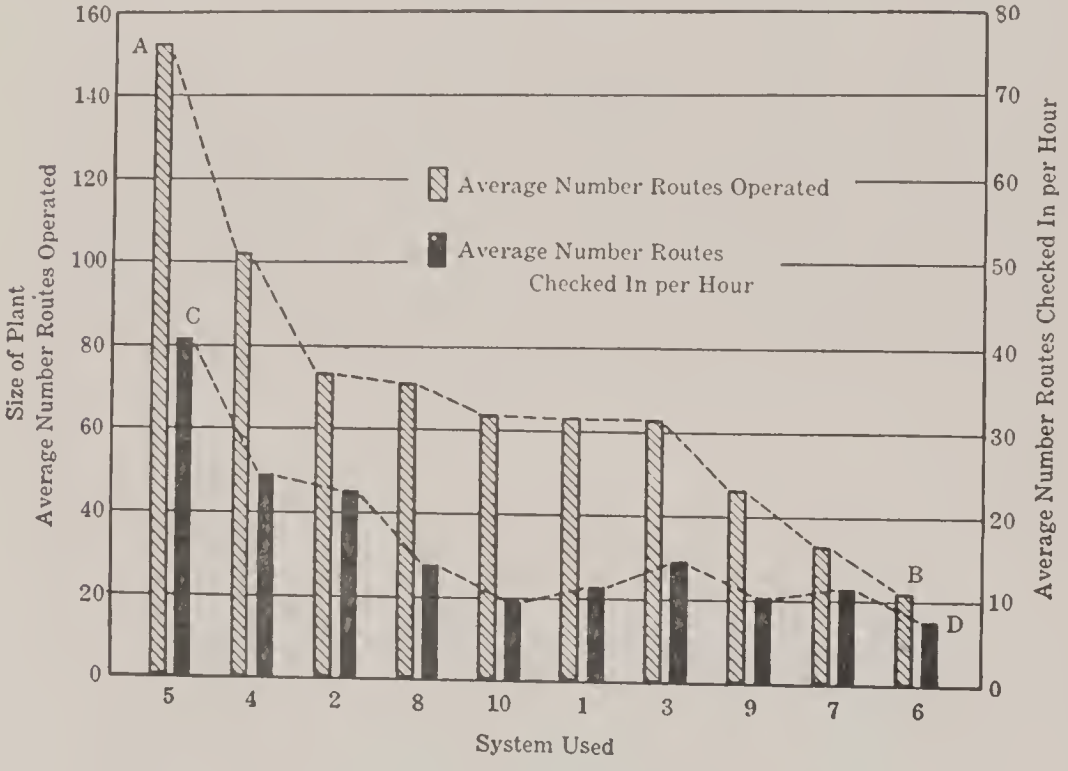


FIG. 73.—Relation of average number of routes checked in per hour (*C–D*) to the size of plant (*A–B*). (3).

is due more to the peculiar arrangement of the particular plants than to the economy of the system. The plants using system 1 were not so arranged and the operations were not so coordinated that the bottles could pass directly to the bottle washers from the checking-in platform. The use of system 10 is restricted to a certain locality where custom and the use of end-door wagons seemed to be the principal reasons for its existence.

Systems 6 and 7, at which the dotted lines in the figure come very close together, are adaptable only to small plants. Where only a few routes are to be checked in, there is no necessity for installing conveyors or for any special arrangement as long as the bottle washer is close to the receiving platform. System 7, as the lines in the figure

indicate, is used at slightly larger plants than is system 6. This is due to the fact that with the former system the cases of bottles are pulled out of the way immediately.

Fig. 74 shows the relation between the number of man-hours required for checking in alone at plants using the systems previously described and the total number of man-hours required for checking in the routes, sorting the bottles, and getting them to the washer.

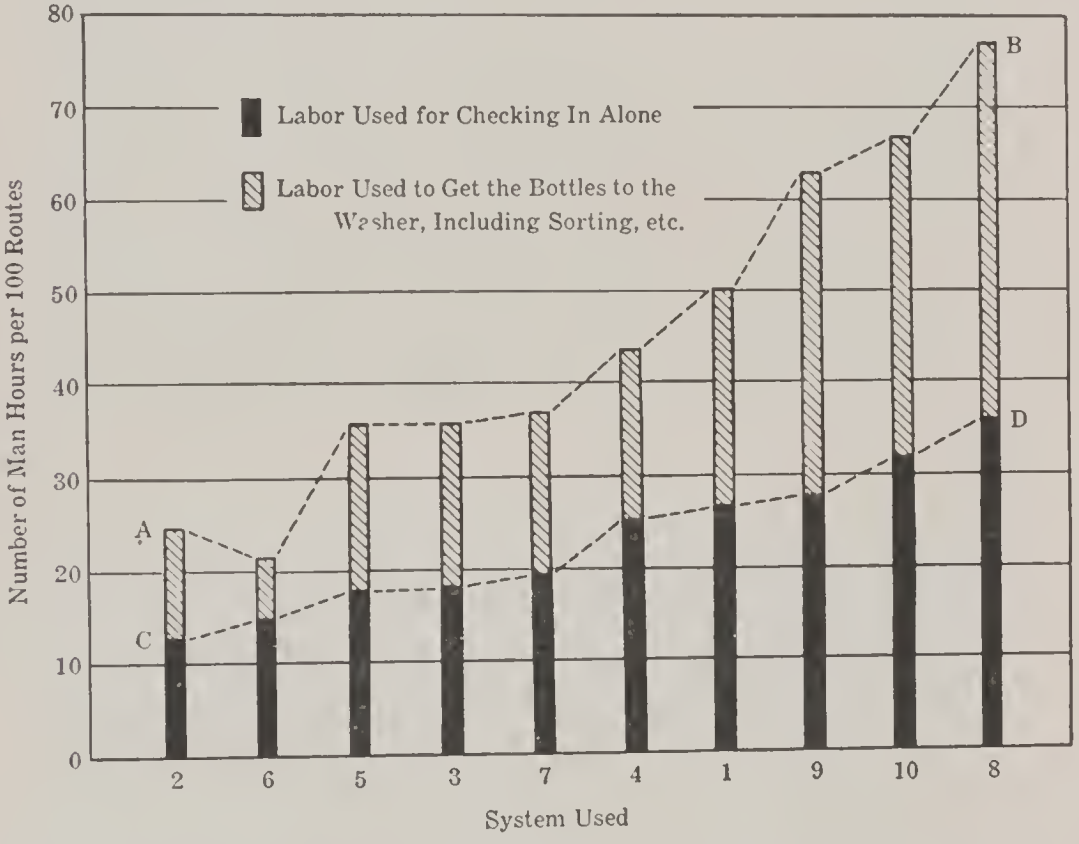


Fig. 74.—Comparison of the labor required for checking in alone (*C–D*) with that required for checking in the routes, sorting the bottles, and getting them to the washers at plants using various systems (*A–B*). (3)

The systems are arranged in order of greatest economy as to labor required for checking in alone.

Fig. 74 shows that a comparatively large amount of labor was required to get the bottles to the washers at the plants using systems 1, 9, 10, and 8. With system 1 considerable time was used to transfer the bottles from the storage room to the washer. Since trucks were used with systems 9 and 10, much handling was necessary before the bottles reached the washers. In the case of system 8, the large number of extra men required in getting the bottles to the washers was due to the transferring from the stacks to the conveyors leading to the washers. Only a small amount of labor was required to get the bottles

to the washer at the plants using system 6 because with this system the bottles are unloaded close to the washer.

FIG. 75.—Checking in routes at a plant using system 10. An average of only 9.7 routes per hour and 3.2 routes per man-hour was checked in at four plants using this system. (3)

FIG. 76.—Checking in routes at a plant using system 9. An average of 10.1 routes was checked in per hour at 10 plants using this system. (3)

CHECKING OUT THE ROUTES

The time required to check out a given number of routes depends a good deal on the system used. In a study carried on at 93 milk plants the following 8 systems for checking out the routes were found: (1) Direct from the storage room through one door or chute; (2) use of barrel or warehouse trucks; [1] (3) direct from the storage room

FIG. 77.—Loading a delivery wagon at a plant checking out routes through two doors or chutes. (Only one chute was in use at the time the photograph was taken.) An average of 13.6 wagons per hour was loaded at 24 plants using this system, and the average time required to load one wagon varied from 2.7 to 7.9 minutes. (3)

through two doors or chutes; (4) use of wheel platform or dolly trucks; [1] (5) use of lift trucks; [1] (6) direct from storage room through three doors or chutes; (7) direct from storage room through four or more doors or chutes; and (8) from seven or more loading points.

COMPARISON OF DIFFERENT SYSTEMS AS TO LABOR AND TIME REQUIRED

Table 72 shows a summary of the results obtained at 93 plants using the eight systems of checking out the routes. The systems in the table are arranged in the order of the number of routes checked

[1] A description of these trucks is given on p. 255.

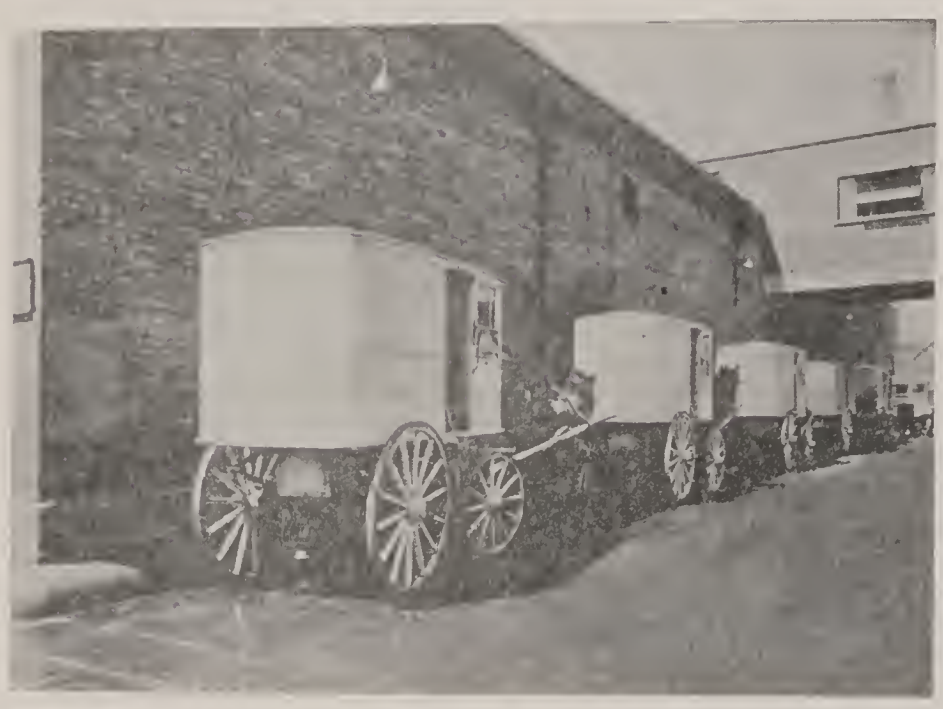


FIG. 78.—Checking out routes at a plant using four or more doors or chutes. An average of 42.3 routes per hour and 4.4 routes per man-hour was checked out at 10 plants using this system. (3)

FIG. 79.—Checking out routes at a plant using seven or more loading points. At seven plants using this system an average of 53.8 routes was checked out per hour. (3)

out per hour. This arrangement is also in accordance with the average number of routes at the plants, except in the case of systems 2 and 5, indicating that as a rule the larger dealers have adopted systems which are the most economical as to the time required.

TABLE 72

COMPARISON OF DIFFERENT SYSTEMS OF CHECKING OUT ROUTES AS TO LABOR AND TIME REQUIRED (3)

Group.	System Used.	Plants.	Routes.			Men Employed.	Hours of Work.
			Wholesale.	Retail.	Total.		
		Number.	Number.	Number.	Number.	Number.	Number.
1	One chute direct to wagon....	19	1.7	23.5	25.2	1.9	2.5
2	Barrel or warehouse trucks....	6	13.8	40.8	54.7	6.0	5.0
3	Two chutes to wagon.....	24	4.1	44.2	48.3	2.9	3.6
4	Wheel platform and dolly trucks.....	6	6.7	45.3	52.0	3.5	3.6
5	Lift trucks.....	7	0.3	33.1	33.4	5.7	1.9
6	Three chutes to wagon.....	14	2.1	77.9	79.9	6.4	2.6
7	Four or more chutes to wagon.	10	9.1	119.9	129.0	8.2	3.1
8	Loading from seven or more points.....	7	2.1	157.3	159.4	13.6	3.0

Group.	System Used.	Man-hours.*	Routes per Hour.†	Routes per Man-hour.		Time Required per Route.	
		Number.	Number.	Number.*	Number.†	Minutes.‡	Minutes.§
1	One chute direct to wagon....	4.9	10.0	5.1	5.1	6.0	6.9
2	Barrel or warehouse trucks....	32.8	10.9	1.7	1.8	5.5	5.7
3	Two chutes to wagon.....	11.4	13.6	4.2	4.5	4.4	4.8
4	Wheel platform and dolly trucks.....	16.8	14.5	3.1	3.8	4.1	8.7
5	Lift trucks.....	16.6	18.0	2.0	3.1	3.3	3.6
6	Three chutes to wagon.....	19.1	30.7	4.2	4.7	2.0	2.0
7	Four or more chutes to wagon..	29.0	42.3	4.4	4.9	1.4	1.5
8	Loading from seven or more points.....	40.5	53.8	3.9	4.0	1.1	1.1

* Man-hours required for putting up orders is included.
† Man-hours required for putting up orders is not considered.
‡ Weighted average.
§ Average of averages.

As a rule the greatest number of men is required to operate the systems which are most efficient as to time required per route. As the number of chutes or loading points is increased, the number of men must be correspondingly increased. It is desirable that all the routes be checked out in three or four hours, and large plants must use several chutes or loading points in order to get the routes out on time, even though more men are required.

EFFECT OF PLANT ARRANGEMENT ON BREAKAGE OF BOTTLES

Studies were made by the Bureau of Dairy Industry at over 150 city milk plants to determine the effect of the plant arrangement and equipment on the bottle breakage. The broken glass was collected at the following points:

1. Checking-in platform.
2. Feed end of washer.
3. Discharge end of washer.
4. Fillers.
5. Milk-storage room.

The glass was weighed and the results expressed in pounds of glass per 1000 bottles filled. The amounts of breakage varied at different plants from 5 pounds to 30 pounds per 1000 bottles filled. Table 73

TABLE 73

COMPARISON OF BOTTLE BREAKAGE AT PLANTS WASHING BOTTLES ON DIFFERENT FLOOR LEVELS

Location of Washer.	Number of Plants.	Bottles Filled. Daily.	Pounds of Glass Broken per 1000 Bottles Filled.		
			Before Washing.	At Discharge of Washers and at Fillers.	Total Plant Breakage.
Street floor	64	41,126	3.7	5.6	10.2
Basement (bottles delivered on street floor by washer itself)	13	68,708	4.8	5.6	11.4
Second floor (bottles sent to street floor to be filled)	17	62,010	5.3	7.3	14.4
Basement (bottles not delivered by washer to the filling room on the street floor)	4	56,079	8.5	13.9	24.3

shows the results obtained at plants with the bottle washers located on different floors. It will be noted that the least breakage occurred where the bottles were washed on the street floor.

The following is a summary of some of the results of the study:

The bottle breakage in the plant depended to a large degree on the plant arrangement and the equipment used.

The size of the plant was not a determining factor in the amount of breakage.

There was a direct relation between the number of transfers from floor to floor and the amount of breakage. As a rule, at plants where bottles were moved to the basement to be washed, the breakage was greater where gravity conveyors were used than where the transfer was made by power-controlled conveyors. Where the bottles were sent upstairs to be washed, both the breakage before washing and the total breakage were greater than where the bottles were washed on the ground floor or in the basement, provided that in the latter case the bottles were delivered on the street floor by the washer itself. Where the filled bottles were transferred to the milk-storage room on a floor below, the breakage in the milk-storage room was greater than where both the filling room and milk-storage room were on the street floor and there was no transfer between floors. At the plants which had the milk-storage room on a floor below the filling room, the breakage was greater when the transfer was made over straight or spiral gravity conveyors than where the transfer was made over power-controlled conveyors.

Both the breakage before washing and the total breakage were greater where trucks were used to transfer the bottles from the checking-in platform to the washer than where conveyors were used to make the transfer with a minimum of stacking of the bottles. Where the bottle washer was located at a point close to the checking-in platform the breakage was less than where conveyors were used. At plants so arranged that there was a large amount of stacking of the bottles from the conveyors, the breakage was greater than at the plants at which the bottles were transferred by trucks.

At plants using the direct system of washing and filling bottles, both the total breakage and the breakage at the discharge of the washers and at the fillers were less than at the plants using the indirect or semi-direct systems. The breakage with the semi-direct system was greater than with the indirect system. Sudden changes in temperatures of heating or cooling media naturally caused breakage of bottles.

When cases of bottled milk were transferred for considerable distances on conveyors, the breakage was greater at the plants using gravity conveyors than at those where power conveyors were used. Where gravity conveyors are used, however, much breakage can be prevented if automatic stops are installed which will shut off the flow of bottles on the conveyor when it becomes full.

Well-designed cases and cases in good repair tended to reduce bottle breakage.

At the particular plants studied, more quarts, on the average, were broken per 1000 handled than containers of other sizes, and more jars than pints per 1000 handled.

Division into Rooms.—From the standpoints of sanitation and economy of operation, a division into rooms is essential. In many small plants, the greater part of the work is done in one room, but in the larger and more modern plants a special room is provided for each operation. Each room should be laid out and constructed for the particular purpose for which it is designed.

Receiving Room.—In the receiving room the milk is inspected, sampled, and weighed. This room contains the weigh tank, scales, and milk-sampling outfit, and should be screened and separate from the other parts of the plant. After the cans are dumped they are drained, washed, steamed, and returned. The can-washing apparatus should be located either in the receiving room or in a room adjoining it.

Handling Room.—In the milk-handling room are usually located the clarifier, pasteurizer, coolers, and fillers and cappers, though in some plants the bottle-filling department is in a room separate from the rest of the handling room. It is important that the milk-handling room be separate from the other rooms.

Bottle-washing Room.—This room should be separate, so that no steam or foul air can pass into the rooms where milk is handled.

Clean-bottle Storage Room.—Between the bottle-washing room and the filling room, some plants have a clean-bottle storage room where bottles are stored after being washed. This room must be cool and kept strictly clean, so that the bottles can cool and be kept free from dust or dirt. This room is not required where the direct system of washing and filling bottles is used.

Milk-storage Room.—A well-insulated cold-storage room is necessary to keep the milk cold after it is put into bottles. The construction of cold-storage rooms is discussed on pages 381 and 382.

Salesroom.—The salesroom at the front of the building should be attractive in appearance and should contain a counter, a refrigerator, and perhaps a few chairs and tables for customers.

Driver's Room.—A room connected with the office should be provided, in which drivers can score their books on returning from the routes. Bath and toilet facilities should also be provided for the drivers and men.

Laboratory.—A laboratory for the bacteriological and chemical examination of milk is essential. Small plants need only a small laboratory, while large ones require a complete laboratory with a full supply of chemical and bacteriological equipment.

By-products Room.—Space should be provided for handling by-products. In small plants, this may be done in the milk-handling room, as only small quantities of butter, cottage cheese, and butter-milk are made.

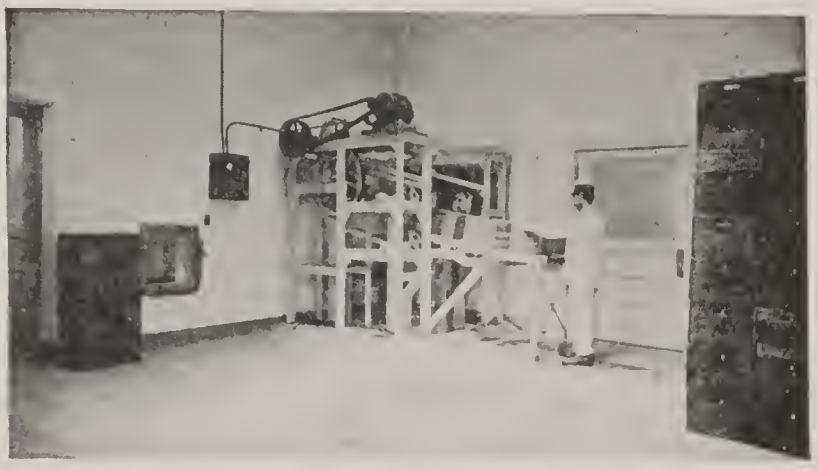


FIG. 80.—Clean bottle storage room.

In medium-sized or large plants, however, one or more separate rooms are required for the by-products department.

Size of Rooms.—Each room in the plant should be large enough to avoid crowding the machinery or workmen, but there should be no

FIG. 81.—Milk sales room at city plant.

unused space, for this causes extra labor in getting from one piece of apparatus to another.

In Table 74 are shown measurements made of five well-arranged plants. An idea may be obtained from this table as to the size of rooms necessary.

TABLE 74

FLOOR SPACE IN VARIOUS ROOMS OF FIVE WELL-ARRANGED PLANTS OF VARIOUS SIZES (1)

Quantity of Bottled Milk Handled Daily. Gallons.	Receiving Room. Sq. Ft.	Bottle-washing Room. Sq. Ft.	Pasteur-izing Room. Sq. Ft.	Bottling Room. Sq. Ft.	Total Area for Receiving, Washing, Pasteurizing and Bottling Rooms. Sq. Ft.	Milk Storage Room. Sq. Ft.	Clean-bottle Storage Room.* Sq. Ft.
1000	400	600	500	300	1800	450	400
1500	.....	700	550	375	1625	550	
3000	900	1050	1300	1200	4450	1200	750
4000	460	1886	540	700	3586	1426	540
6000	1200	1908	720	720	4548	1110	720

* Where the direct system of washing and filling bottles is used, this room is not needed, but this space would be added to the bottle-washing room.

FIG. 82.—Drivers' room at city milk plant.

Even in these modern plants, there is no uniformity as to the size of the rooms in relation to the quantity of milk handled. The size required will, of course, depend also on the methods of handling the milk. The plant handling 4000 gallons daily had a comparatively small pasteurizing room, although the total area of the handling rooms was ample. The plant handling 3000 gallons daily had space enough to handle considerably more than this quantity. The milk-storage room and clean-bottle storage room in the plant handling 6000 gallons daily were hardly

large enough for this quantity of milk, but some of the milk was sent out directly on the delivery wagons, and so less storage space was required.

FIG. 83.—Milk plant laboratory for checking the chemical and bacterial quality of milk received and sold.

The figures in the table, besides giving an idea of the space required, also effectually illustrate the lack of standardization, even in modern milk plants.

REFERENCES

(1) Kelly, Ernest, and Clement, C. E., City Milk Plants: Construction and Arrangement, 1920. U. S. Dept. Agri. Bul. 849.
(2) Milk Plant Letters. Bur. of Dairy Ind., U. S. Dept. Agri.
Parker, H. N., City Milk Supply, 1917.
Milk Plant Letters, Dairy Division, U. S. Dept. Agri.
(3) Clement, C. E., Le Fevre, P. E., Bain, J. B., and Grant, F. M., Effect of Milk Plant Arrangement and Methods of Operation on Labor Requirements. U. S. Dept. Agri. Tech. Bul. 153, 1929.

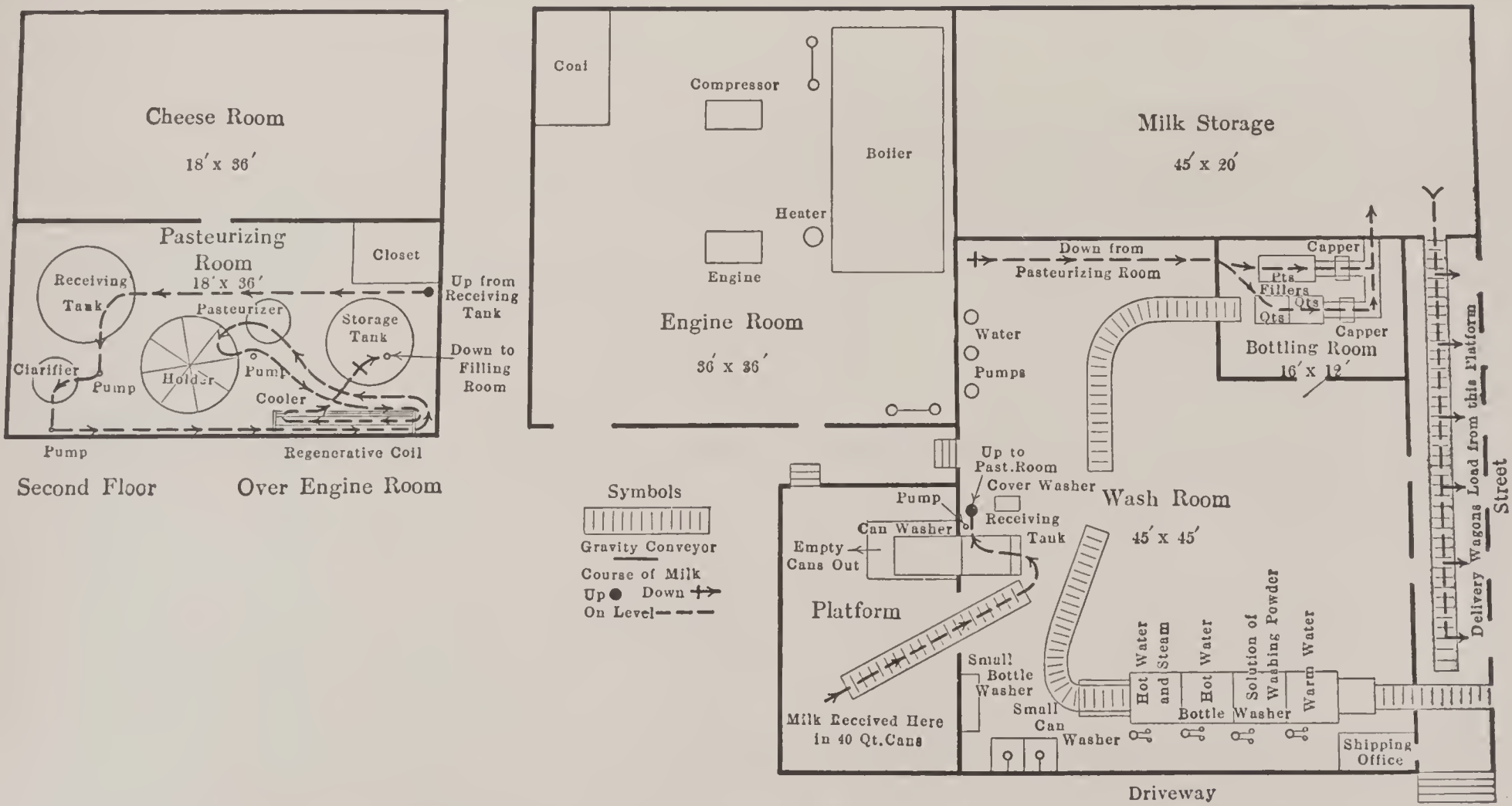


FIG. 84.—Floor plans of plant handling approximately 4000 gallons of milk daily, illustrating economical use of space by the careful arrangement of rooms and equipment. The floor space in this plant is less than one-third as great, and the labor only about half as great, as that at another plant of three stories handling about the same quantity of milk. Milk pumps and piping are, however, excessive.

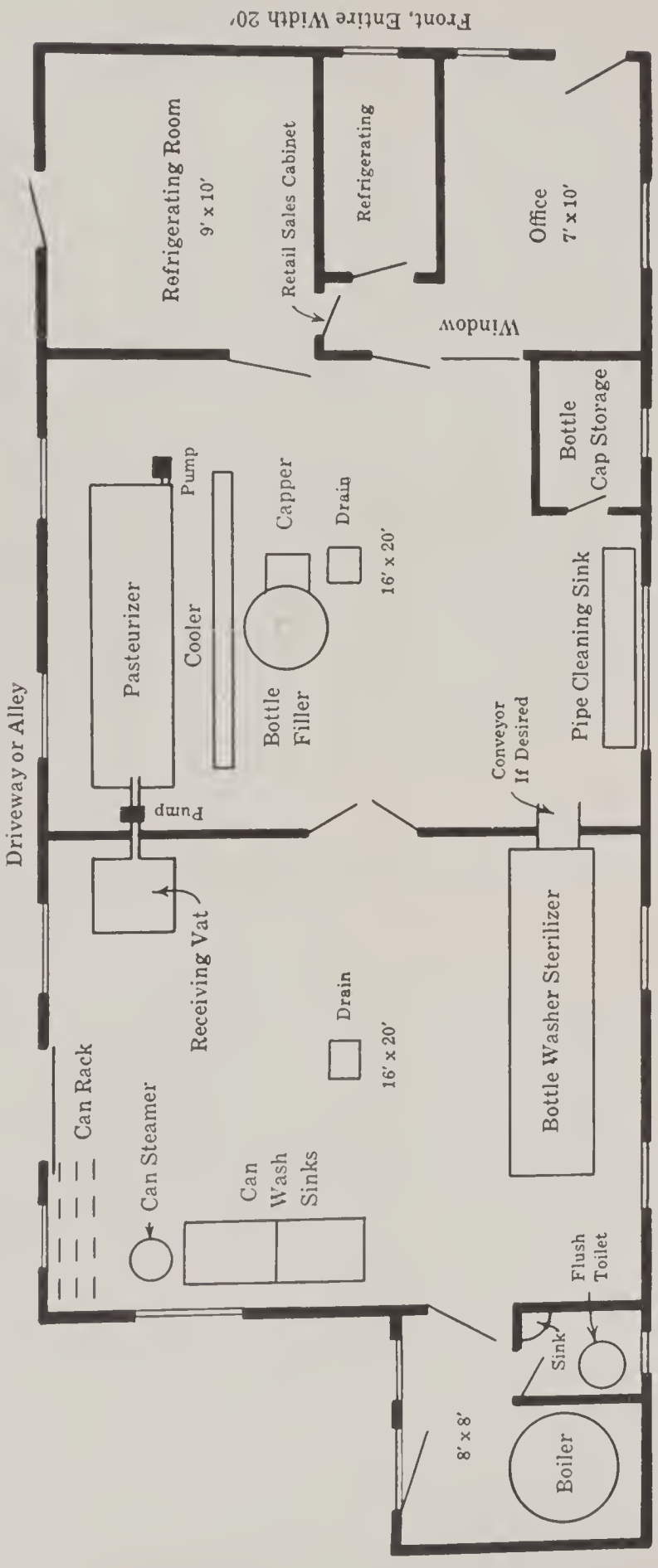


FIG. 85.—A suggested floor plan of a pasteurizing plant adequate for handling 1000 quarts of milk or less daily.*

* New Jersey Dept. of Health, Trenton, N. J.

FIG. 86.—First floor plan of a modern milk plant.

* Where the direct system of washing and filling bottles is used, the clean-case room would not be required. This space could then be added to the bottle-washing room.

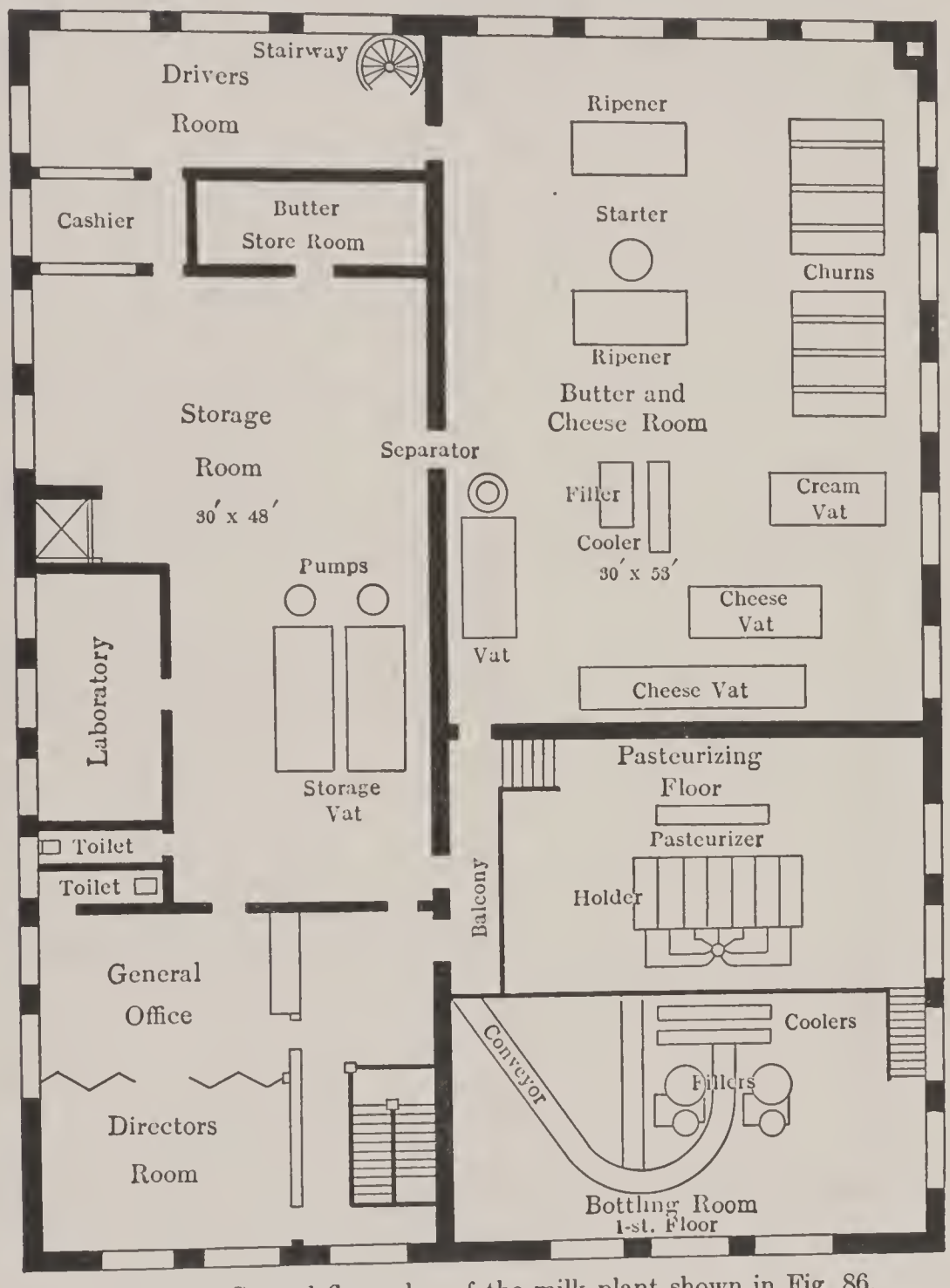


FIG. 87.—Second floor plan of the milk plant shown in Fig. 86.

CHAPTER XVII

MILK-PLANT EQUIPMENT

SELECTION OF EQUIPMENT (1)

BEFORE making plans for the establishment of a new milk plant or the rearrangement of an old one the amount and type of equipment to be used should be decided upon. Too much or too complicated apparatus is often provided. In many cases the capacity of the machines is either too great or too small for the quantity of milk to be handled. Such mistakes are usually detected after it is too late. The following points should be considered when selecting the equipment:

Simplicity.—The equipment should contain the fewest number of parts to do the required work efficiently.

Ease of Cleaning and Treating to Kill Bacteria.—It is important that all milk apparatus be cleaned and treated to kill bacteria daily. If this work is to be done easily and properly the equipment must have few inaccessible parts.

Ease and Economy of Operation.—Unless a machine can be operated economically it will be a liability to the owner rather than an asset. If it can be operated easily, comparatively little attention to it will be required.

Durability.—Apparatus of poor quality usually is costly in the end; durability is an important factor.

Initial Cost.—Although cheap apparatus seldom proves satisfactory, it is not always necessary or advisable to buy the highest-priced equipment. The initial cost, however, is an important factor to be considered.

Proper Capacity.—The equipment should be of sufficient capacity to handle all probable increase of business. Milk-plant equipment, however, depreciates rapidly, and it is therefore not advisable to procure oversize apparatus which will not last until the anticipated increase has taken place.

Proper Material.—All apparatus with which milk comes in contact must be of a material that will not impart a metallic or off flavor to the milk and will not result in any chemical or electrolytic action. Tinned copper and glass-enameled and nickel equipment are satisfactory and are most commonly used. Some other metals and alloys which have been used in recent years have proved satisfactory.

DEPRECIATION OF EQUIPMENT (1)

The life of milk-plant equipment depends upon the original condition, amount of use, and the care given it. As a rule it receives

hard and constant usage and depreciates very rapidly. Furthermore, improvements in milk-plant equipment are constantly taking place. It, therefore, becomes obsolete after a few years and must be replaced by more modern equipment.

Table 75 gives a tabulation of the replies to a questionnaire sent to 267 milk-plant operators regarding the average annual depreciation of various pieces of equipment at their plants. With the exception of the power-plant equipment, the most common depreciation for the different equipment was from 15 to 20 per cent per year. The most common depreciation for bottle fillers was 20 per cent. In most plants, therefore, this equipment will last only about five years before it must be replaced. Bottle washers last slightly longer, 16.6 per cent being the most common depreciation. Fifteen per cent annual depreciation was most commonly given for pasteurizing apparatus, and many plants have as low a depreciation as 10 per cent. Power-plant equipment generally lasts longer than other equipment required for milk plants because it is more durable and does not become obsolete so quickly. Ten per cent per year was most commonly given as the depreciation for this class of equipment.

TABLE 75

ANNUAL DEPRECIATION OF VARIOUS PIECES OF EQUIPMENT AT MILK PLANTS OF DIFFERENT SIZES (1)

Number of Gallons of Milk Handled Daily.	Total Number of Plants.	Per Cent Annual Depreciation of—											
		Bottle Washers.			Bottle Fillers.			Pasteurizer and Cooler.			Power-plant Equipment.		
		Average.	Range.	Most Common.	Average.	Range.	Most Common.	Average.	Range.	Most Common.	Average.	Range.	Most Common.
500 or less....	30	14.8	10–25.0	10.0	15.7	10–33.3	20	14.5	8.5–25.0	10.0	12.4	5–25	10
501 to 1,000..	27	15.1	5–25.0	15.0	15.0	8–25.0	20	14.0	10–20.0	10.0	13.0	5–25	10
1,001 to 2,000.	39	15.9	5–25.0	15.0	17.3	8–25.0	20	15.3	5–25.0	15.0	13.6	8–25	10
2,001 to 3,000.	26	14.8	6–25.0	15.0	15.9	10–25.0	20	13.9	6–25.0	15.0	12.2	6–20	10
3,001 to 5,000.	43	15.8	7–25.0	16.6	18.5	7–50.0	20	15.8	7–25.0	16.6	12.3	5–24	10
5,001 to 10,000	56	15.9	7–30.0	20.0	17.5	10–30.0	20	15.3	8–25.0	15.0	11.3	5–25	10
10,001 to 20,000	26	16.2	10–25.0	16.6	19.6	10–33.3	20	16.0	10–25.0	20.0	12.1	6.5–25	10
Over 20,000....	20	16.0	10–33.3	16.6	18.4	12.5–33.3	20	15.8	8–33.3	16.6	9.7	5–15	10
Total or average	267	15.6	5–33.3	16.6	17.3	7–50.0	20	15.1	5–33.3	15.0	12.1	5–25	10

EQUIPMENT REQUIRED (1)

In general, the following list represents the principal equipment required for the typical city milk plant:

Weigh can and scales.
Can washers.
Receiving vat.
Storage tanks or vats.
Clarifier or filter.
Pasteurizing and cooling equipment, with apparatus for controlling and recording the temperatures.
Fillers and cappers.
Bottle washers.
Sanitary milk pumps, piping, etc.
Labor-saving devices, such as conveyors and elevators.
Boilers, engines, refrigerating machinery, motors, etc.
Cans, bottles, crates, etc.

Weigh Can and Scales.—At very small plants the milk may be weighed in the cans in which it is received, in which case the weigh can itself will not be needed.

FIG. 88.—Weigh can and scales in use. (Sample rack at left.)

At medium-sized and large plants either a single or double compartment weigh can may be used; but when milk is received from

a large number of producers much time may be saved by the use of a double-compartment can. The valves through which the milk is released from the weigh can should be large so that the milk will run out quickly and the operator will not be delayed by waiting.

In all cases, whether milk is bought by the gallon or by the pound, it should be weighed. If it is bought by the gallon the weight may be readily converted to gallons; in fact, there are scales on the market which record the quantity in gallons as well as in pounds.

After the milk of each producer is emptied into the weigh can a sample is taken for the purpose of determining the butterfat content.

Fig. 89.—Equipment for making Babcock test.

A sample rack is shown in Fig. 88, and laboratory equipment for determining the butterfat content is shown in Fig. 89.

Can Washers.—In washing cans first rinse them in cold water to remove milk adhering to them, then wash them in hot water containing a washing powder, rinse in hot water, steam, and dry. In small plants the cans may be washed as follows: After being rinsed in cold water they are immersed in a tank containing a hot washing solution. They are then washed inside and outside with a brush, after which they are transferred to another tank and rinsed in clean hot water. Finally, they are placed over a jet through which hot water and steam are forced into them. Each can should be steamed at least 45 seconds, or

until it will dry immediately. Very satisfactory results may be obtained with this system of washing cans if the work is properly done.

Large plants must have can washers that are as nearly automatic as possible and in which a large number of cans can be washed in a short time. The so-called hydraulic can washer (Fig. 90) is most commonly used. This washer consists of a series of tanks containing alkali powder washing solutions and rinsing waters. As the cans travel in an inverted position through the machine they pass over a series of jets through which the washing solutions and rinsing waters are forced from the tanks below by means of powerful pumps. Next they pass over steam jets through which live steam is blown into them.

FIG. 90.—Hydraulic jet can washer (powerful pumps are used with this type of washer, but these are not shown in this illustration).

The next step is the drying of the cans, which is accomplished by a blast of hot air generated by blowing air through a chamber containing steam pipes. The drying of the cans is very important, for it not only improves their sanitary condition but also prevents rust and thus prolongs their usefulness. The hydraulic can washers may be of either the straightaway or the circular type, the latter having the advantage of requiring less floor space.

Many can washers have a device in the first section into which any milk remaining in the can drains and is saved. Where such washers are not in use a separate apparatus for saving the milk should be provided, because a drip saver considerably reduces losses of handling milk at the plant. The apparatus may be homemade or it may be purchased from a dairy-supply house. Collecting pans to catch the

drip should be placed under all apparatus where milk is apt to spill and especially under the filling machines. Although the milk saved should not go back to the filler, it may be utilized in other ways. Table 76 shows the quantity of milk saved by drip savers at several plants.

TABLE 76

QUANTITY OF MILK SAVED BY DRIP SAVERS AT SEVERAL PLANTS

Plant No.	Quantity of Milk Dumped.	Quantity of Milk Saved with Drip Saver.	
	Gallons.	Gallons.	Per Cent.
1	6000	16	0.266
2	4000	15	.375
3	3000	12	.400
4	2000	6	.300

Receiving Vat and Storage Tanks or Vats.—From the weigh can the milk is released by a valve and flows by gravity to a receiving vat. Only a small vat is necessary if provision is made for storage tanks and a pump of sufficient capacity to pump the milk to the storage tanks as

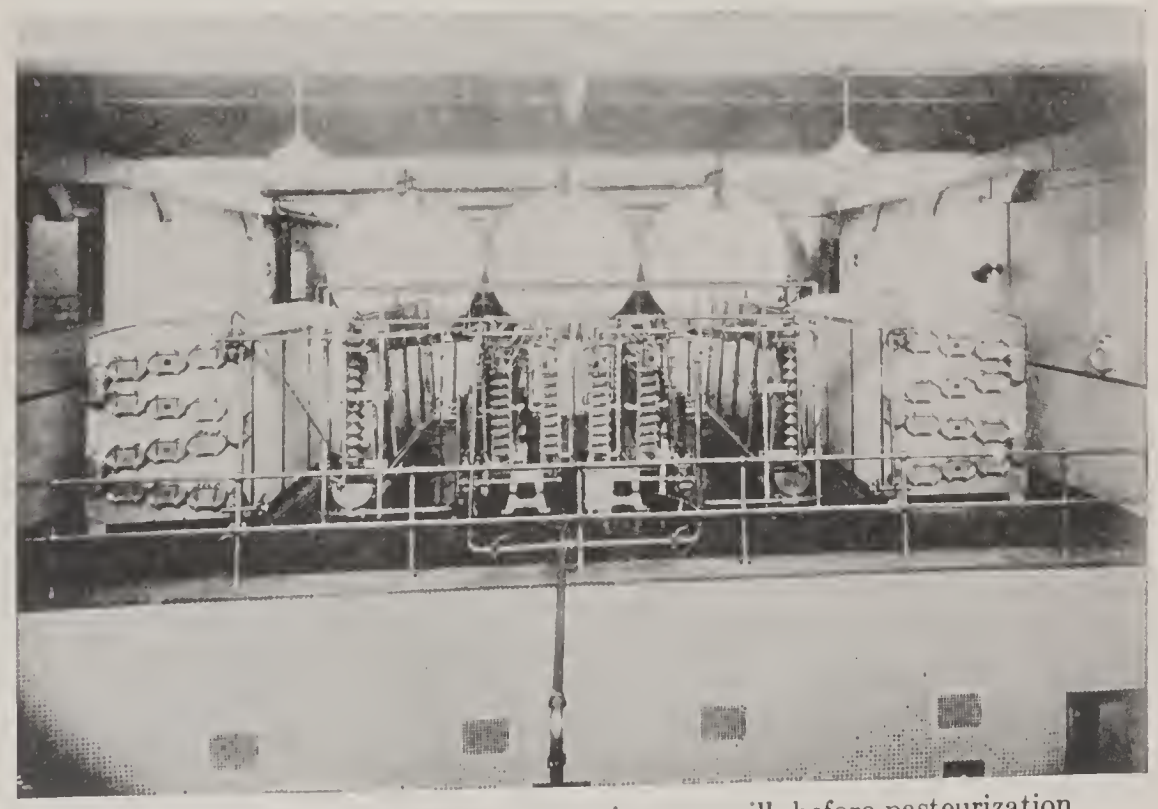


FIG. 91.—Milk-storage tanks for storing raw milk before pasteurization.

fast as it comes from the weigh can. At small plants a large receiving vat may be used and the milk pumped from it direct to the pasteurizing department. A larger receiving vat will be required if a continuous system of pasteurization is used than if the vat system of pasteurization is employed, as in the latter case the milk may go direct to the pasteurizing vats, but with the former system some of the milk must be held in the receiving vat so that a uniform flow to the pasteurizer may be maintained. Such a receiving vat may be provided with revolving coils containing a cooling medium. These coils also mix the milk received from various producers.

At large plants the milk generally goes from the receiving vat to large storage tanks or vats either by gravity or by means of a pump. The pump should be large enough to handle the milk as fast as it is received without being forced and should be of sanitary construction. Storage tanks such as those shown in Fig. 91 are often used at large plants. These tanks are usually provided with an outside jacket in which a cooling medium can be circulated and the milk held at a low temperature. They are usually lined with enamel or other smooth material so that they can be readily cleaned and heat treated. These tanks may be installed either vertically or horizontally, the latter system being somewhat more desirable from the standpoint of accessibility for cleaning. At many plants milk is held for several hours before it is pasteurized, and in such instances a great saving in cans, refrigeration, labor, and floor space is effected by the use of these storage tanks.

Clarifier or Filter.—The clarifier is used to remove from the milk dirt or other foreign matter. This is retained in the machine as the milk passes through it.

Table 77 shows the number of plants of various sizes clarifying milk at specified locations. The temperatures of clarification are also shown. It will be noted that most of the plants either clarified the milk cold as it came from the producers or from the storage tanks, or used a preheater, in which case the milk was clarified at temperatures usually between 80° and 90° F. Clarifying cold milk tends to produce more foam than when a preheater is used. High temperatures, however, have a tendency to injure the cream line. Recent improvements in the machines permit the use of the low temperature without the formation of much foam.

At only one plant was the clarifier placed between the heater and the holder, and at only two plants was the milk clarified after the pasteurization process was completed. The latter is not a desirable practice, as the milk should reach the bottles as soon as possible after pasteurization with a minimum of intervening apparatus.

TABLE 77

NUMBER OF PLANTS OF VARIOUS SIZES CLARIFYING MILK AT SPECIFIED LOCATIONS AND TEMPERATURES

Number of Gallons of Milk Handled Daily.	Total Number of Plants.	Plants in which Clarifying was Done—							
		Between Receiving Tanks and Pasteurizer, with no Preheating.			Between Preheater and Pasteurizer.*			Between Heater and Holder, at Pasteurizing Temperature.	Between Pasteurizer and Cooler, at Pasteurizing Temperature, with no Precooling.
		Number of Plants.	Temperature (°F.)		Number of Plants.	Temperature (°F.)			
			Average.	Range.		Average.	Range.		
500 or less...	8	5	57.6	50–63	3	90.0	85– 95	0	0
501 to 1,000..	7	5	57.0	55–60	2	97.5	95–100	0	0
1,001 to 2,000.	5	2	60.0	55–65	2	85.0	85	0	1
2,001 to 3,000.	9	2	55.0	55	6	88.0	75– 95	1	0
3,001 to 5,000.	12	5	62.8	39–85	6	83.8	70– 95	0	1
5,001 to 10,000	9	2	65.0	35–95	6	105.0	90–115	0	0
10,001 to 20,000	5	4	47.3	40–50	1	90.0	90	0	0
Over 20,000....	1	.....	.....	.....	1	70.0	70	0	0
Total or average.....	56	26	57.8	35–95	27	91.0	70–115	1	2

* In some cases no extra equipment for preheating was used, as a section of the pasteurizer was "by-passed" for this purpose.

The clarifier should be large enough to handle the milk as fast as it is received. It is much better that the machine be too large than too small, as in the latter case the milk, if properly clarified, cannot be sent to the pasteurizers and bottling machines as fast as they can handle it.

The filter (page 348, Fig. 117), is another apparatus designed to remove the visible dirt from the milk. Various materials are used, but the most common are cotton pads or cloth with a long-fiber nap on both sides.

Table 78 shows the number of plants of various sizes filtering milk at the specified locations. The temperatures of filtration are also shown. The most common location was between the preheater and the pasteurizer. Milk can be filtered efficiently by this method, and there is no opportunity to recontaminate the milk by the filter after the milk has been pasteurized. As a general rule less efficient results are obtained by filtering the milk cold than by first heating it. Although milk can be filtered efficiently at the pasteurizing temperature, it is

TABLE 78

NUMBER OF PLANTS OF VARIOUS SIZES FILTERING MILK AT SPECIFIED LOCATIONS AND TEMPERATURES

Number of Gallons of Milk Handled Daily	Total Number of Plants	Plants in Which Filtering Was Done—													
		Between Receiving Tanks and Pasteurizer, with no Preheating			Between Preheater and Pasteurizer *			Between Heater and Holder, at Temperature of—				Between Pasteurizer and Cooler			
												With Precooling			At Pasteurizing Temperature, with no Precooling
		Number of Plants	Temperature (° F.)		Number of Plants	Temperature (° F.)		145° F.	144° F.	143° F.	140° F.	Number of Plants	Temperature (° F.)		
			Average	Range		Average	Range						Average	Range	
500 or less	30	6	65.0	55–70	5	98.0	85–125	1	2	1	0	4	107.5	60–130	11
501 to 1,000	18	3	61.0	55–70	5	106.0	90–120	1	0	0	1	1	125.0	125	7
1,001 to 2,000	37	6	56.7	50–60	7	99.0	90–120	6	0	4	1	6	125.0	100–135	7
2,001 to 3,000	30	3	55.0	50–60	13	96.5	70–137	3	0	1	1	2	129.0	125–133	7
3,001 to 5,000	31	9	39.0	38–40	13	102.3	85–130	1	2	3	0	0	.....	.....	3
5,001 to 10,000	49	10	39.1	38–40	21	110.1	90–125	4	2	3	3	0	.....	.....	6
10,001 to 20,000	28	2	49.0	40–58	9	119.0	106–130	2	7	3	0	0	.....	.....	5
Over 20,000	22	0	....	.....	10	115.6	100–125	1	8	2	0	0	.....	.....	1
Total	245	39	19.2	38–70	83	106.5	70–137	19	21	17	6	13	120.2	60–135	47

* In some cases no extra equipment for preheating is used, as a section of the pasteurizer is "by-passed" for this purpose.

more desirable from a sanitary standpoint to filter it before it has been heated to this temperature, and in no case is it desirable to filter it after pasteurization has been completed.

Many types of filters and clarifiers which do very efficient work are on the market.

Milk Pumps.—One or more milk pumps are necessary in most milk plants. It is very important that they be of proper construction and kept clean. Practically no injury to the cream line seems to be caused by pumping the cold, raw milk or the hot, pasteurized milk. Pumping at intermediate temperatures, however, especially between 60° and 100° F., is to be avoided, as it tends to injure the cream line.

Some of the troubles encountered with milk pumps are due to faulty installation. The centrifugal pump should be used only when the milk flows directly to the pump. It lifts the milk several feet and works satisfactorily in pumping the milk over the cooler, provided the

pump is so placed that the milk flows to it. Other common types are the piston and the rotary pumps, the latter being adaptable where suction is required. A properly operating piston pump agitates the milk very little and should give good results.

Pasteurizing Machinery.—The various types of heaters and holders are considered in Chapter XX, " Pasteurization of Milk."

FIG. 92.—Open-surface milk cooler.

Coolers.—Two types of coolers are in common use—the open-surface tubular cooler (Figs. 92 and 113) and the internal-tubular cooler (Figs. 91 and 97). With the open-surface cooler the milk passes over the tubes in a thin film and the cooling medium passes through these tubes. This cooler is so constructed that water can be used in the top sections and brine or direct-expansion ammonia in the bottom sections. Where the regenerative system of pasteurization is used the cold, raw milk is often allowed to pass through the inside of the first sections of the cooler.

With the open-surface cooler the milk is exposed to the air in the room, and for that reason the air should be kept pure. If the cooler is covered contamination from the air will be reduced. It is more desirable, however, to have pure air in the room where the cooler is located, as considerable care is required to keep the covers clean and they are often clumsy to handle. If covers are used the sterilization of the cooler is made easier.

The internal-tubular coolers are constructed on the same principle as the internal-tubular heaters; that is, the milk passes through a pipe which is itself inclosed in a pipe or jacket containing the cooling

medium. The number of cooling coils required is about double that of heating coils. With this type of cooler the milk does not come into contact with the air at any time. There is no loss of milk from evaporation, therefore, whereas there may be some loss from this source with the open cooler, especially if it is in a draft.

It is easier to sterilize the internal-tubular cooler than the open-surface cooler. If steam is introduced into the former and the apparatus closed it can be thoroughly sterilized. One way to sterilize the surface cooler is to admit steam to the inside of the tubes and at the same time run hot water over the outside of the cooler. The hot water will be vaporized and quite thorough sterilization will result. A somewhat better cream line can be obtained with the open-surface cooler.

Table 79 shows the number of plants of various sizes using the specified kinds of coolers. Tubular coolers were used in the great majority of plants, and the open-surface coolers were somewhat more common than the internal-tubular coolers. This is especially true in the case of the smaller plants. At three plants the milk was entirely cooled in vats. This is not a desirable practice because of the danger of injuring the cream line. Three of the plants used a cooler which consists of a conically shaped drum over the outside of which the milk flows in a thin film with the cooling medium on the inside.

The capacity of the milk cooler should be ample to cool the milk as fast as it comes from the holder.

TABLE 79

NUMBER OF PLANTS OF VARIOUS SIZES USING SPECIFIED SYSTEMS OF COOLING MILK

Number of Gallons of Milk Handled Daily.	Total Number of Plants.	Plants Cooling Milk with—			
		Open-surface Tubular Cooler.	Internal-tubular Cooler.	Vat Cooler.	Cone Cooler.
500 or less	33	28	3	2	0
501 to 1,000	32	25	6	0	1
1,001 to 2,000	45	30	15	0	0
2,001 to 3,000	38	24	14	0	0
3,001 to 5,000	46	26	20	0	0
5,001 to 10,000	59	27	30	1	1
10,001 to 20,000	30	18	11	0	1
Over 20,000	21	12	9	0	0
Total	304	190	108	3	3

In practically all milk coolers the temperature of the hot, pasteurized milk is first reduced by cold water. In the milk regenerative system [1] it is first reduced by the incoming cold, raw milk. To precool by water, coolers are so constructed that water can be used as the cooling medium in the first section. In some cases there are two sections for the circulation of water, permitting its more economical use. In the remaining section either direct-expansion ammonia or brine is used as the refrigerating medium. In the first case the liquefied ammonia as it comes from the compressor is expanded directly into the cooling coils and the change to the gaseous state absorbs the heat from the milk flowing over the outside of the cooler. A special type of steel tube must be used in direct-expansion coolers. In the brine system the brine, which usually consists of a solution of calcium chloride or of common salt, is pumped from a tank through the cooling coils. As this solution has a low freezing point, a low temperature can be maintained without danger of freezing the solution. The temperature of the brine is maintained by expanding the ammonia into coils which are placed in the brine tank or in a separate brine cooler. Table 80 shows the number of plants of various sizes using the specified systems of cooling milk.

TABLE 80

NUMBER OF PLANTS OF VARIOUS SIZES USING SPECIFIED SYSTEMS OF COOLING MILK*

Number of Gallons of Milk Handled Daily.	Total Number of Plants.	Plants Cooling Milk with—			
		Brine.	Direct Expansion.	Both Brine and Direct Expansion.	Ice-Water.
500 or less	34	30	3	0	1
501 to 1,000	31	24	6	0	1
1,001 to 2,000	41	31	7	3	0
2,001 to 3,000	35	27	6	2	0
3,001 to 5,000	47	35	10	1	1
5,001 to 10,000	60	50	10	0	0
10,001 to 20,000	32	23	9	0	0
Over 20,000	21	14	6	1	0
Total	301	234	57	7	3

* In all cases water was used as the cooling medium in the first section.

[1] See pages 350 and 351.

Brine was by far the most common cooling medium, 234 plants out of a total of 301 using this method of cooling. Only 57 plants used the direct-expansion method. Among the advantages of the use of brine over the use of the direct-expansion system alone are the following: (1) Its greater elasticity—the brine can be stored for cooling after the refrigerating machine has been shut down or in case of a breakdown; (2) the fact that there is less danger of freezing the milk on the cooling pipes; and (3) the fact that special tubes are not required and there is less danger of leakage.

The direct-expansion system has the advantages of (1) greater economy at plants where it is necessary to run the machine continuously, as less refrigeration will be lost if the ammonia goes directly to the cooler than if it goes through the secondary brine medium; (2) simpler operation; and (3) smaller initial expenditure required for equipment.

At some plants direct-expansion coils are used in the milk-storage room, and brine is circulated from a tank, usually in the storage room,

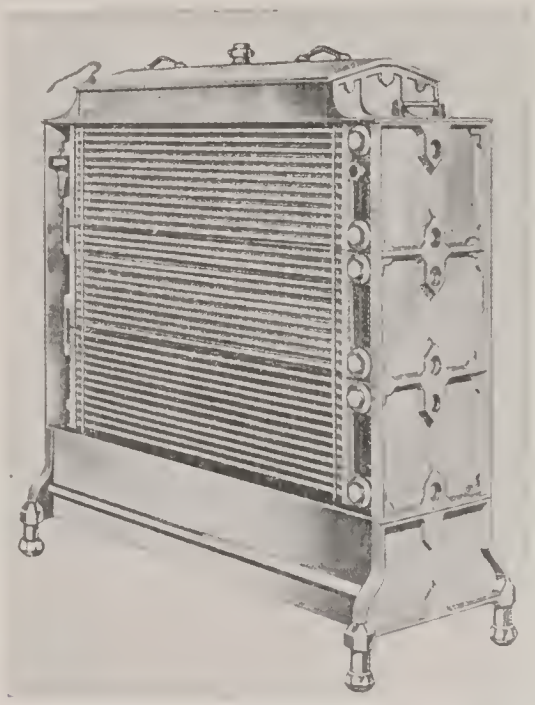


FIG. 93.—Cabinet Cooler with one cover removed, showing side unit of three sections.

through the milk cooler. Whether direct expansion or brine is used in cooling the milk, it is always desirable to use water in the first few coils of the cooler, as refrigeration is thus saved. In some plants, instead of using brine or direct expansion for cooling the milk, water cooled by means of brine coils or direct expansion coils is used. In this way the temperature of the cooling medium is accurately regulated, and extreme temperatures are avoided.

The Cabinet Cooler.—The so-called cabinet cooler has recently come on the market. It is a self-enclosed outfit consisting of several series of 1-inch tubes. The number of series or units of tubes varies from 7 to 11 for coolers of rated capacities of from 12,000 to 20,000 pounds per hour. One of the chief advantages of this cooler is the small floor space required. It is also comparatively easily cleaned, as the units of tubes can be moved out of the framework of the apparatus. Fig. 93

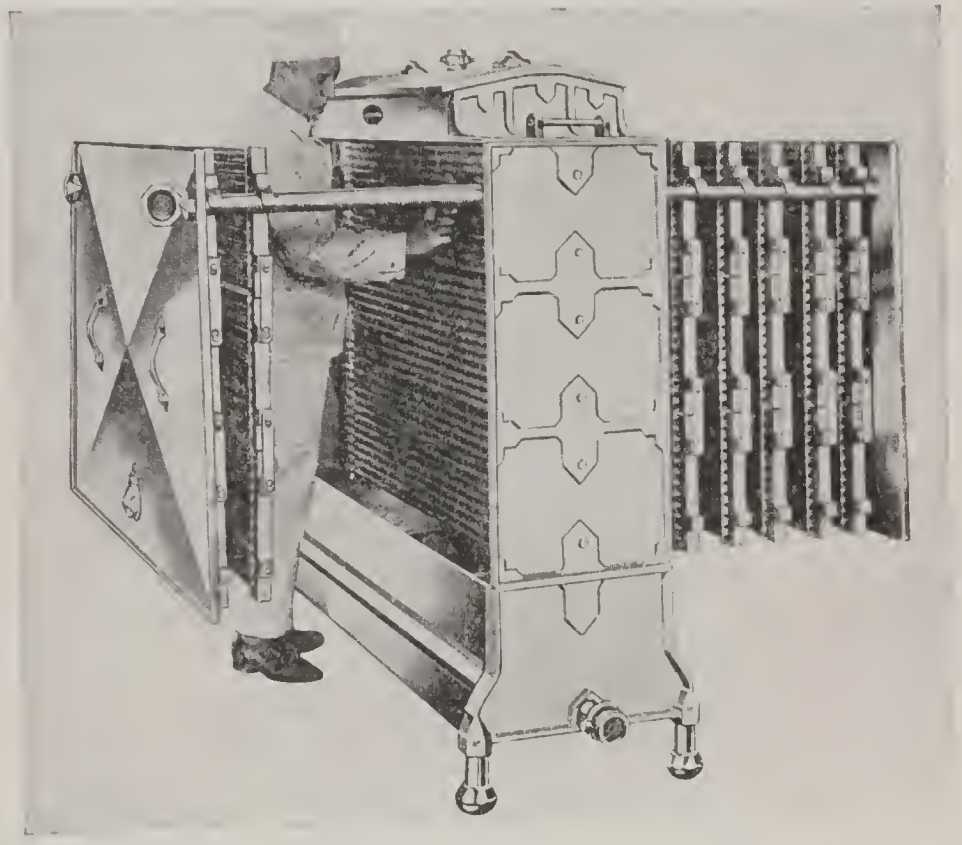


FIG. 94.—Showing the accessibility of Cabinet Cooler for cleaning or inspection.

shows the cooler with one cover removed, and Fig. 94 shows the method of cleaning this cooler.

Bottle Washers.—In general there are three types of bottle washers —the small brush washer, the hydraulic-pressure in-the-case bottle washer, and the soaker type of washer.

The small brush washer consists of (1) a tank, which is filled with the washing solution in which the bottles are allowed to soak; (2) a brush, which is made to revolve by steam turbine, motor, or belt power and onto which the bottle is forced by the operator (in some cases three brushes in a row are used so that the bottle is brushed on the outside as well as on the inside); (3) a chamber in which a case of bottles, after being brushed, is inverted for the purpose of rinsing with hot water and steam. With some machines this is accomplished

by means of a two-way valve through which first hot water and then live steam are forced into the bottles. Other machines are provided with a pump which forces hot water into the bottles. This type of washer is suitable only for small plants and is not in very general use.

The hydraulic-pressure in-the-case bottle washer (Fig. 104) consists of a series of tanks containing washing-powder solutions and rinsing waters. These waters are forced through small jets into the bottles by powerful pumps. Usually the first tank contains a lukewarm rinsing water, the

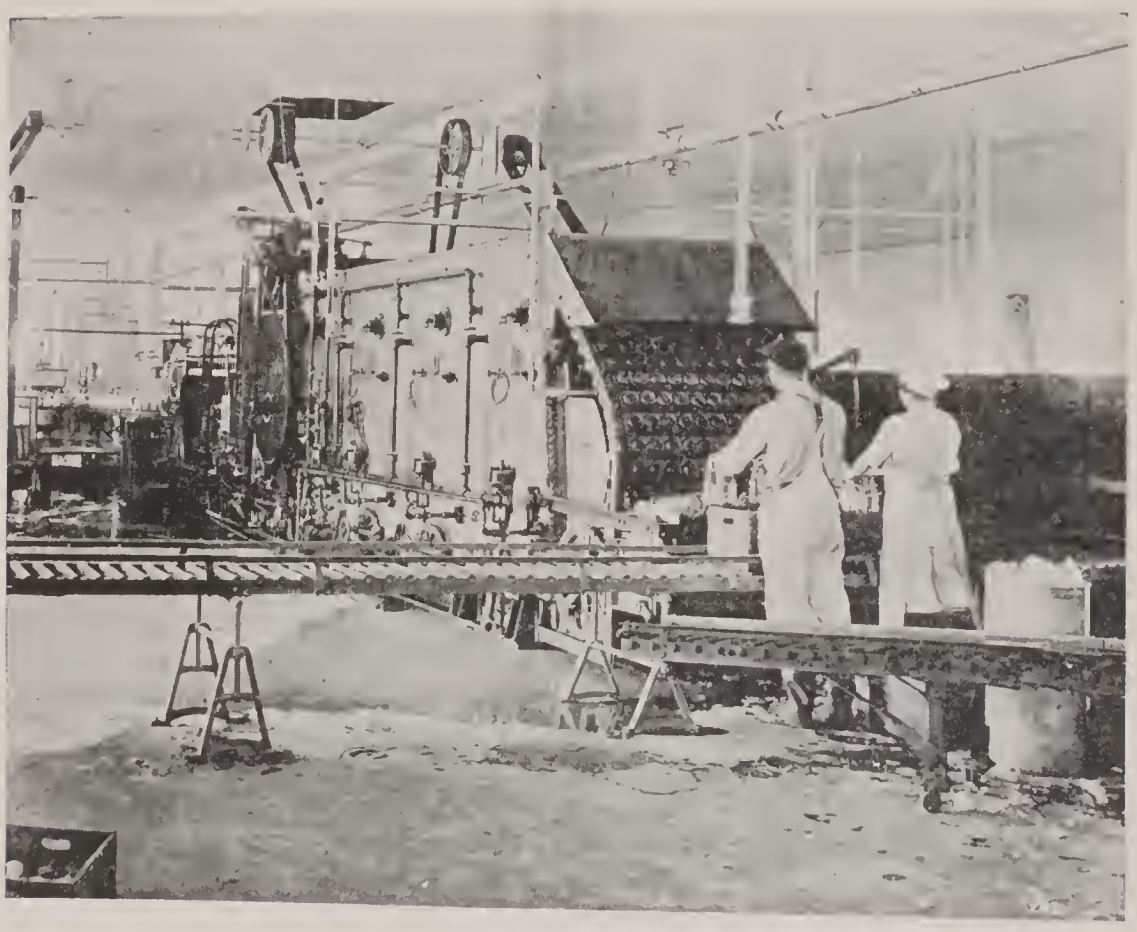


FIG. 95.—A soaker type bottle washer in use.

second tank the washing solution, and the other tanks hot rinsing waters. The temperature of the last water is at or near the boiling point, and in some cases the bottles receive a spray of steam. One man usually feeds the cases of bottles into the machine and another man takes them out at the other end and piles them in stacks so they will cool. Junk bottles or other very dirty bottles are sometimes not readily cleaned by these machines. Such bottles should be soaked in a strong washing solution and washed first with a brush machine and then sent through the pressure washer for rinsing and steaming.

It is very important that the proper temperature is maintained

in each tank. The temperature of the solution in the first tank must not be so high as to break the bottles, and it should be increased in each tank so that the final one will be kept at a temperature near the boiling point. Care must also be taken to have the proper solutions in each tank. In large machines the first tank contains a strong alkali solution, the second a milder solution, and the remaining tanks rinsing water.

In the soaker type of bottle washer (Fig. 95) the bottles are removed from the cases and fed into the machine, where they are prerinsed and

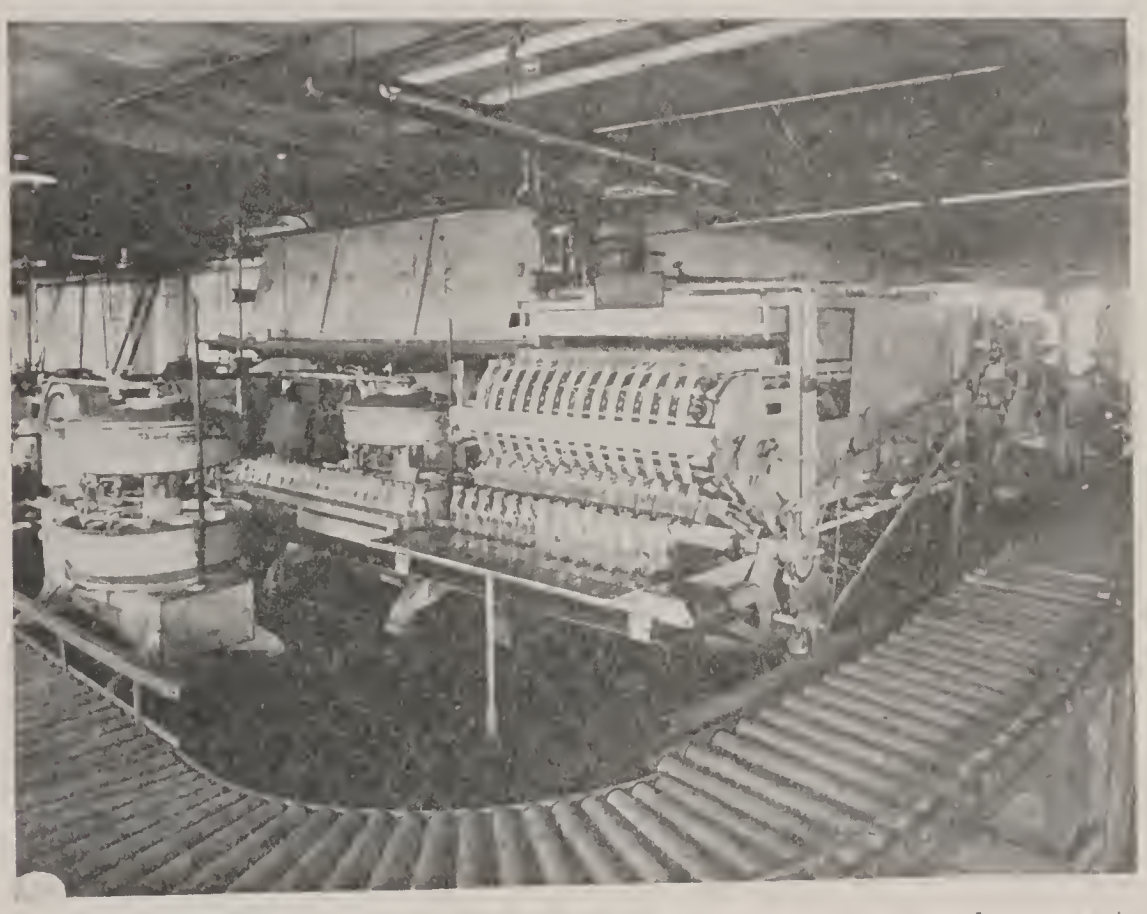


FIG. 96.—Discharge end of a soaker type bottle washer. The bottles are automatically conveyed to the fillers at the left.

then soaked or sprayed with two or more solutions containing strong alkali, which acts both as a cleaning and as a bacteria-killing agent. The temperature of the various solutions is gradually increased.

After this process the bottles are brushed on the outside. In some types they are brushed on the inside also. Where no brushes are used on the inside of the bottles the bottles are subjected to sprays of hot water under high pressure. With one type air is mixed with these sprays, thus forming an "air brush."

Rinsing waters are then forced into the bottles. The temperatures

of these waters are gradually reduced, and when the bottles come from the final water they are cool enough to be filled immediately. In some cases a bacteria-killing agent is used in the final rinsing water.

After the bottles come from the machines (Fig. 96) they are transferred by conveyors directly to the fillers. The cases, when empty, are placed on a conveyor which carries them through a case washer and thence to the fillers. Considerable economies in labor of washing and filling the bottles are effected with this system, as no handling of the bottles between the washers and fillers is required.

Table 81 shows the number of plants of various sizes using the specified systems of washing bottles. At the time this survey was made (1927) the plants were about equally divided between the soaker type and the in-the-case type of bottle washers. The use of the latter, however, is gradually being discontinued in favor of the former, which requires less labor for washing and filling the bottles. The breakage of bottles is also less, as there is not so much handling of bottles and the temperatures are usually controlled more accurately.

Only a few small plants were using the brush washers.

TABLE 81

NUMBER OF PLANTS OF VARIOUS SIZES USING SPECIFIED SYSTEMS OF WASHING BOTTLES

Number of Gallons of Milk Handled Daily.	Total Number of Plants.	Plants Using Specified Type of Bottle Washer.		
		Soaker Type.	In-the-case Washer.	Small Brush Washer.
500 or less	34	2	23	9
501 to 1,000	31	4	25	2
1,001 to 2,000	44	16	28	0
2,001 to 3,000	35	24	11	0
3,001 to 5,000	46	24	22	0
5,001 to 10,000	58	34	24	0
10,001 to 20,000	30	23	7	0
Over 20,000	22	21	1	0
Total	300	148	141	11

Fillers and Cappers.—After the milk has been pasteurized and cooled it is bottled and sealed ready for delivery to the consumer. For this

purpose fillers and cappers are required. Formerly fillers which were operated by hand levers were used, and the bottles were frequently capped by hand. At present, however, at practically all plants automatic fillers and cappers are used. In their operation there is no necessity for the milk or the cap to come in contact with the human hand. The rotary fillers and cappers are the most common (Fig. 97).

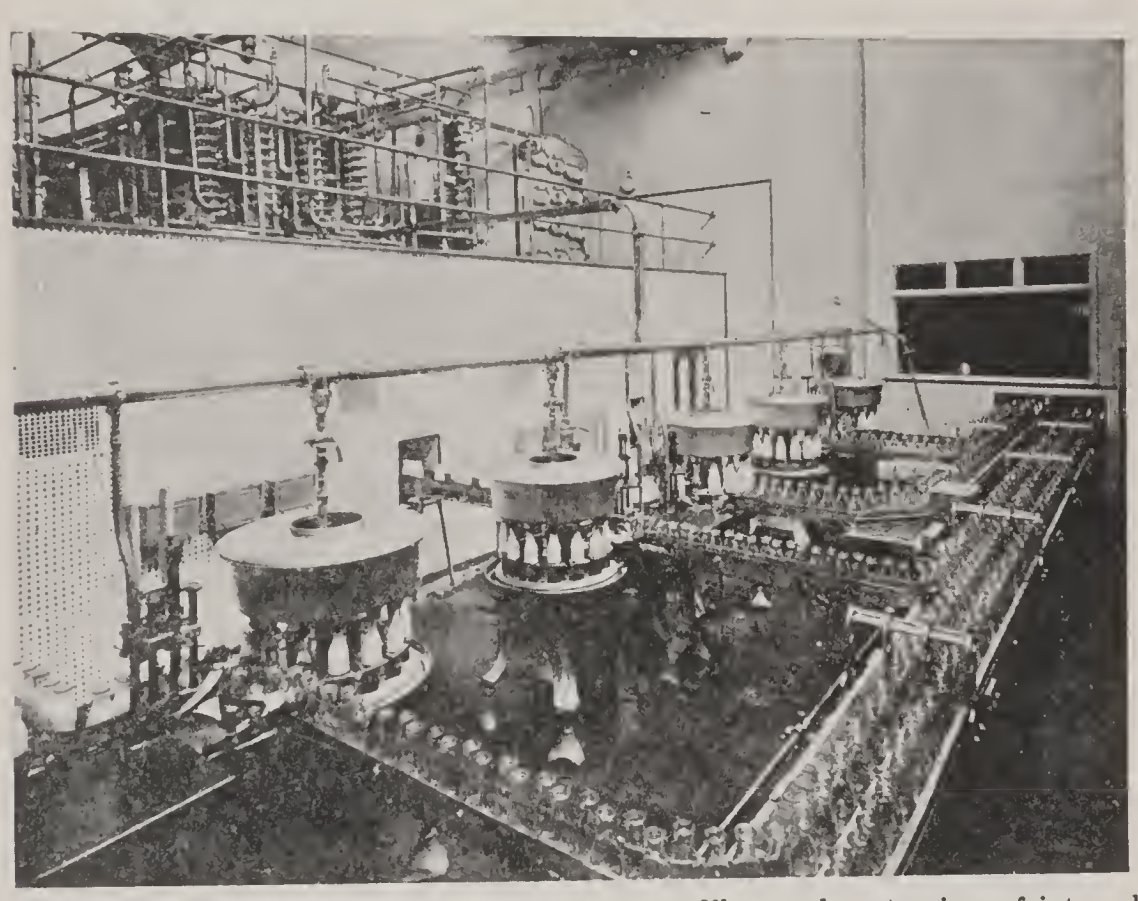


FIG. 97.—View in bottling room showing rotary fillers and pasteurizer of internal-tubular type.

This machine consists of a circular tank with valves similar to those in other types of fillers. Each bottle is automatically raised as it comes under the valve and the milk flows into it. When the bottle has traveled the full revolution of the tank, it is automatically lowered and the valve closes. The bottles are then carried to the capper, which caps them automatically. Tubes extending from the top of the tank to the valve allow the air to escape and prevent foam. Several sizes of these machines are on the market and the tanks have six or more valves. From 24 to 72 bottles may be filled and capped per minute, depending on the size of the machine. In operating the larger machines of this type where the continuous system of washing and filling is not used, one man is required to feed the machine and another to take the filled bottles away. Only one man is required to operate

the smaller machines. Large plants have a battery of three or more of these machines (Fig. 98).

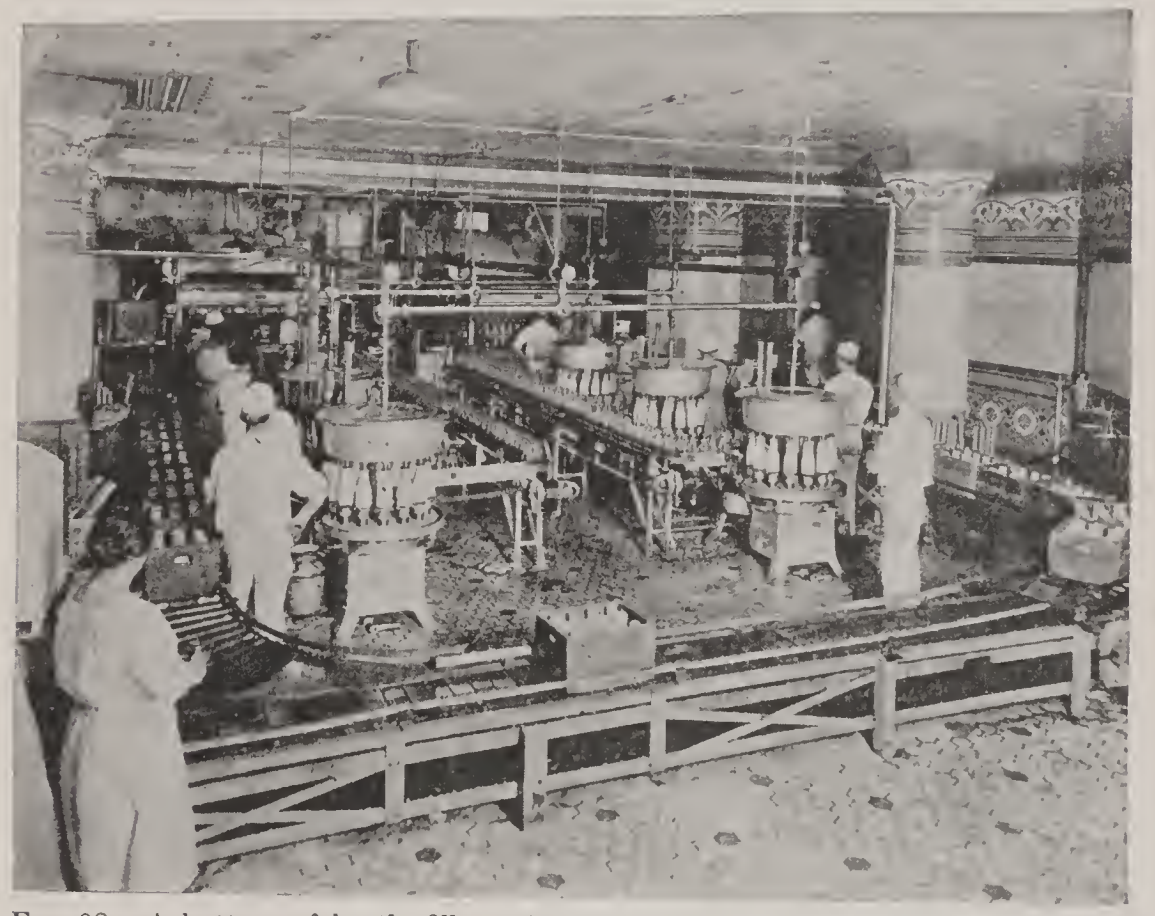


FIG. 98.—A battery of bottle fillers of the rotary type. Bottles are moved automatically to the fillers on conveyors from the discharge end of the soaker-type bottle washers.

TABLE 82

NUMBER OF PLANTS OF VARIOUS SIZES USING SPECIFIED SYSTEMS OF FILLING AND CAPPING BOTTLES

Number of Gallons of Milk Handled Daily.	Number of Plants.	Plants Using Specified Type of Bottle Filler.		
		Rotary System.	Case System.	Single-row System.
500 or less	31	31	0	0
501 to 1,000	31	31	0	0
1,001 to 2,000	45	44	0	1
2,001 to 3,000	35	35	0	0
3,001 to 5,000	51	49	1	1
5,001 to 10,000	60	59	0	1
10,001 to 20,000	30	29	0	1
20,001 and over	22	21	0	1
Total	305	299	1	5

Table 82 shows the number of plants of various sizes using specified systems of filling and capping bottles. It will be noted that at practically all plants the rotary type of filler is used.

Labor-saving Devices.—Considerable labor can often be saved by the use of devices such as elevators and conveyors. Some conveyors operate by gravity, others by power. Although such equipment is expensive, conveyors to bring the milk from the receiving platform to the dump tank will save considerable handling, as will also conveyors to bring the bottles from the checking-in platform to the washers and to convey the filled bottles from the filling room to the milk-storage room and out to the delivery wagons.

POWER PLANT (1)

The power plant should be entirely separate from the milk department and is often in another building. It is important that the boiler room be far enough away and so inclosed that dirt, soot, or gases cannot reach the milk-handling rooms. The power plant should be of ample capacity for all anticipated requirements. It may be advisable for large plants to have an extra boiler and an extra refrigerating machine. Power may be saved at certain times of the year by operating only one of the machines when the full capacity of refrigeration is not needed. Having two boilers makes it possible to clean or repair one of them without shutting down the plant.

Steam or Electric Power.—Whether a steam engine or electric motors should be used will depend largely upon the costs of current and coal. The use of motors has several advantages, and direct-connected motors for each machine are advisable wherever possible, although where several machines are grouped together less power will be required if only one motor is used to run the shafting for all the machines. At large plants electric current to run the motors can often be generated for less than it can be bought. Some of the advantages of direct-connected motors are:

Simplicity of operation.
Cleanliness.
Use of power only when machine is operated.
Small space required.
Accuracy with which amount of power used in operating a machine may be determined.
Elimination of insanitary hangers, shafting, and pulleys.

The following are some of the advantages of the use of steam engines in milk plants:

The source of power is under the control of the milk plant.

An additional steam boiler need not be purchased, since one must be used to supply steam for hot water, pasteurizing, sterilizing, and for heating the building.

The exhaust steam can be utilized for heating water to be used in the plant.

Whatever power is used it is well to have an auxiliary system, so that if anything happens to one system the plant will not have to be shut down. A plant using electric power should have an engine or extra motors for an emergency, and for the same reason a plant using steam power should install electric motors.

Mechanical Refrigeration.—Most large plants use mechanical refrigeration, but many smaller ones still depend upon ice. Individual conditions will determine which will be more economical to use.

The advantages of mechanical refrigeration are discussed in Chapter XXII.

EQUIPMENT REQUIRED FOR VARIOUS-SIZED PLANTS (1)

On the following pages are lists of the principal equipment required for plants of various sizes and the approximate total cost. These figures on cost are given only as a guide for comparison. The cost of equipment will depend a great deal on the type of machinery selected, kind of contract made, and the character of the business. As prices are continually changing, only approximations can be made as to the cost of equipment. The number of milk cans and bottle cases required will depend upon the individual plant, but in these lists is given the approximate quantity that would be needed.

Principal Equipment for Plant of 100-Gallon Capacity

One platform scales (double beam).
One pasteurizer (100-gallon vat).
One temperature recorder.
One sanitary milk pump.[1]
Sanitary piping and fittings.
One tubular milk cooler (capacity 1500 pounds an hour).
One bottle filler.
One turbine-brush bottle washer with tank, rinser, and steamer.
One can wash sink with steam jet.
One small separator.
One small churn.
Milk cans (for delivery to wholesale trade).
Two sets of bottle cases.
One brine tank.

[1] The number of pumps required will depend on the plant layout.

One brine pump.
One 3-horsepower motor.
One 10-horsepower boiler.
Steam and water hose and fittings; shafting, belting, pulleys, hangers, piping, fittings, etc.
Babcock tester (12-bottle size).

Estimated total cost of the plant equipment, from $2500 to $3000.

An initial supply of about 3000 bottles, also bottle caps, washing powder, and coal will be necessary.

Principal Equipment for Plant of 500-Gallon Capacity

One platform scales (beam or dial type).
One weigh can, with cover, strainers, and splash hood.
One receiving vat (capacity 150 gallons), with cover, strainer, and agitator. (If vat pasteurizers are used, a receiving vat of less capacity could be used.)
One filter.
One pasteurizing and cooling outfit, with automatic temperature control and recording thermometers.
One or two sanitary milk pumps.[1]
One bottle filler.
One small bottle washer and sterilizer.
One can washer, rinser, and steamer.
One separator (capacity 2000 to 2500 pounds per hour).
One small churn and butterworker.
One brine tank.
One brine pump.
Milk cans.
Two sets of bottle cases.
Trucks, conveyors, etc.
One 5-horsepower motor.
One 20-horsepower boiler.
Sanitary milk piping and fittings.
Belting, shafting, pulleys, hangers, piping, fittings, etc.
Steam and water hose with fittings.
Chemical apparatus.

Estimated total cost, from $8000 to $10,000.

If mechanical refrigeration is used, an additional investment of $1500 to $2000 will be required.

An initial supply of about 15,000 bottles, also bottle caps, coal, and washing powder, will be necessary.

Principal Equipment for Plant of from 1000- to 1500-Gallon Capacity

One 2-compartment dump and weigh can, with cover, strainer, splash hood, and two 3-inch gates.

[1] The number of pumps required will depend on the plant layout and on the type of pasteurizing equipment used.

One scales (beam or dial type).
One or two sanitary milk pumps.[1]
One receiving vat (capacity 300 gallons), with cover, strainer, and agitator.
One milk-storage tank (1000 gallons capacity).
Pasteurizing and cooling outfit, with automatic temperature control and recording thermometers (capacity, 4000 pounds an hour).
One clarifier or filter (4000 to 6000 pounds an hour).
Sanitary milk piping and fittings.
One filler and capper.
One small filler for buttermilk.
One bottle washer (48 to 60 bottles per minute).
One can washer, rinser, steamer, and drier.
One separator (2000 to 2500 pounds per hour).
One 50-gallon cream vat.
One buttermilk vat.
One churn and butterworker, butter printer, ladles, packer, and starter can.
Milk cans.
Milk-bottle cases.
Trucks, conveyors, etc.
One 20-ton mechanical refrigeration plant, with compressor, brine tank, piping, brine pump, etc.
One 20-horsepower engine, or motors (if electric power is available).
One 60-horsepower boiler with all necessary fittings and accessories (allowing three hours to pasteurize and cool 1200 gallons milk).
Shafting, pulleys, belting, hangers, piping, pipe fittings, valves, etc. (If live steam were used for pasteurizing the boiler capacity would have to be increased.)
Chemical apparatus.
Bacteriological apparatus.

Estimated total cost, from $25,000 to $30,000.

Principal Equipment for Plant of Approximately 5000-Gallon Capacity

One 2-compartment dump and weigh can, with cover, strainers, splash hood, and two 4-inch gates.
One scales (overhead lever type).
One receiving vat, with cover, agitator (motor drive), and strainer (capacity, 300 to 500 gallons).
One or two clarifiers or filters (12,000 pounds an hour combined capacity).
One or two jacketed storage tanks (about 2500 gallons each).[2]
Pasteurizing and cooling equipment (10,000 pounds an hour), with automatic temperature regulator and recording thermometers.
One small pasteurizer for cream.
One small tubular cooler for cream.

[1] The number of pumps required will depend on the plant layout and on the type of pasteurizing equipment used.

[2] The capacity of the receiving vat and the number of storage tanks required will depend on how the milk comes in and the system of pasteurization used.

Two or more sanitary milk pumps.[1]
Sanitary milk piping and fittings.
Three fillers and cappers.
One small filler for buttermilk, etc.
One or two bottle washers (80 to 120 bottles per minute).
One can washer, rinser, steamer, and drier.
One forewarmer.
One separator (capacity, 8000 to 12,000 pounds an hour).
One 300-gallon jacketed vat.
One rotary pump for skim milk.
One combined churn and butterworker (capacity, 1000 pounds butter) butter printer, ladles, packers, etc.
Milk cans and bottle cases.
Trucks and conveyors.
One starter can.
One 300-gallon ripener.
One 500-gallon standardizing and mixing vat.
One 300-gallon cheese vat.
Two drain racks.
One buttermilk machine (300-gallon capacity) (motor drive).
One 50-ton mechanical refrigeration plant, with compressor, brine tank, piping, brine pump, etc.
One 60-horsepower engine, or 70-horsepower motor, to run compressor.
Two 125-horsepower boilers (one in reserve), with all necessary accessories and fittings (5000 gallons of milk to be pasteurized at the rate of 10,000 pounds an hour in from four to four and one-half hours).
One 25-horsepower engine, or motors.
Belting, shafting, pulleys, hangers, piping, pipe fittings, valves, etc.
Chemical apparatus.
Bacteriological apparatus.

Estimated total cost, from $70,000 to $80,000.

A homogenizer or viscolizer for special coffee cream might be included at an additional cost of $1500 to $2500.

Bacteriological Apparatus for Milk Plant

One autoclave, medium size.
One dry-sterilizing oven, gas stove, and kitchen oven.
One incubator, 10 by 0 by 6 inches, inside dimensions.
One balance, with weights to 5 kilos.
One hundred 1-cubic-centimeter pipettes, graduated in tenths, with an extra tenth above the 0 mark.
One 5-cubic-centimeter pipette.
One 10-cubic-centimeter pipette.
One 25-cubic-centimeter pipette.
One 100-cubic-centimeter pipette.

[1] The number of milk pumps required will depend on the plant layout and on the type of pasteurizing equipment used.

One 100-cubic-centimeter cylinder, graduated.
One 500-cubic-centimeter cylinder, graduated.
One 1000-cubic-centimeter cylinder, graduated.
Two dozen Erlenmeyer flasks, 1,000 cubic centimeters.
One hundred Petri dishes, 100 by 10 millimeters.
Four dozen glass bottles, 8 ounces, prescription or French square.
Two funnels, glass, 6-inch.
One double boiler, one-half-gallon.
One thermometer (−10° to 100° C.).
One thermometer (0° to 250° C. for dry sterilizer).
One dozen glass stirring rods (assorted).
Two Petri dish holders, sheet iron, 50 dishes.
Two pipette boxes.
One reading glass, $2\frac{1}{2}$ magnifications, 4 inches.
One counting plate.
One tallying machine.
One gas stove, single burner.
Two Bunsen burners.
Twelve feet gas tubing, $\frac{1}{4}$-inch.
Two wax pencils, blue or red.

Approximate cost, $500.

Chemicals and Accessories for Bacteriological Examination

One liter sodium hydroxide, tenth normal.
One liter sodium hydroxide, normal.
One liter hydrochloric acid, tenth normal.
One liter hydrochloric acid, normal.
Absorbent cotton.
Non-absorbent cotton.
Canton flannel for filtering.
Filter papers.
Peptone.

Chemical Apparatus for a Milk-Plant Laboratory

One Babcock milk tester from 12 to 36 bottles, hand or steam operated.
Three dozen milk-test bottles, 8 per cent.
One dozen cream-test bottles, 50 per cent.
Two pipettes, 17.6 cubic centimeters.
One combined acid bottle and pipette.
One lactometer (Quevenne).
One burette, 50 cubic centimeters, graduated in tenths.
One burette holder.
One dozen beakers, 150 cubic centimeters.
One dropping bottle, 30 cubic centimeters.
One cream-test scale.
One pipette, 10 cubic centimeters.

One pipette, 25 cubic centimeters.
One-half dozen skim-milk test bottles.

Approximate total cost, from $75 to $100.

Chemicals for Chemical Analysis of Milk and Cream

Sulphuric acid, commercial, one-half gallon.
Phenolphthalein, 1 per cent solution, 100 cubic centimeters.
Sodium hydroxide, tenth normal, 1 liter.

Office Equipment.—Besides the articles listed above, office equipment will be required. Small plants require only a desk of some kind, with chairs and possibly an adding machine, check protector, and a safe. Larger plants also require typewriters, computing machines, filing cabinets, and most of the equipment required in a modern business office.

Delivery Equipment.—The delivery equipment required will depend on the type of trade served and where it is located, automobile trucks often being used economically for wholesale trade. The horse and wagon, however, is the most common method of delivering to the retail trade, for which purpose it has many advantages over the automobile. One man can deliver a load of milk from a horse-drawn wagon, but usually at least one extra man will be required on an automobile truck. Moreover, the constant stopping and starting that is necessary on a retail milk route is not favorable to the use of an automobile for delivery in congested sections.

The quantity of goods that can be delivered with one outfit will depend primarily on the distance between customers, the method of delivery, the number of flights of stairs to be climbed, etc. In the ordinary city, where there is more or less competition, about 75 gallons of milk, with the usual quantity of cream, etc., are usually carried by a retail wagon. For wholesale trade, one delivery outfit will handle 500 to 1500 quarts, depending on the type of streets, nearness of the customers, etc.

INVESTMENTS IN MILK PLANT EQUIPMENT

Table 83 shows the investments in plant equipment at 125 plants. These data are based on prices existing in 1916–1917 and therefore the actual figures are not accurate for present conditions. They give an idea, however, as to the relative investments for plants of various sizes.

REFERENCES

Parker, H. N., City Milk Supply, 1917.
Kilborne, The Pasteurization of Milk from the Practical Viewpoint, 1916.
Ayres, S. H., Pasteurization of Milk. U. S. Dept. Agri., B. A. I. Cir. 184, 1912.
Milk Plant Letters, U. S. Dept. Agri.
(1) Clement, C. E., and Grant, F. M., Equipment for City Milk Plants. U. S. Dept. Agri. Cir. 99, 1929.

TABLE 83

INVESTMENTS IN PLANT EQUIPMENT AND MACHINERY FOR PLANTS OF VARIOUS SIZES (2) *

Quantity Handled Daily.	Number of Plants.	Total Gallons Handled Daily.	Average Number Gallons Handled Daily.	Total Investment in Plant Equipment and Machinery.	Average Investment in Plant Equipment per Plant.	Variation.	Average Investment in Plant Equipment per 100 Gallons Handled Daily.	Variation.
100 gallons or less	8	570	71	$ 7,458	$ 932	$ 500–$ 1,311	$1308	$625 to $1714
101 to 250	16	3,028	189	31,735	1,983	400– 5,000	1048	212 to 2500
251 to 500	29	11,565	399	141,045	4,864	1,181– 15,700	1219	348 to 3140
501 to 1,000	23	17,985	782	211,031	9,175	3,200– 20,000	1173	400 to 2500
1,001 to 1,500	15	19,440	1,296	245,069	16,338	4,000– 33,000	1261	333 to 3182
1,501 to 2,000	9	16,400	1,822	242,750	26,972	7,500– 60,000	1480	469 to 5000
2,001 to 3,000	5	12,983	2,597	146,339	29,268	10,000– 47,856	1127	260 to 2175
3,001 to 5,000	9	36,850	4,094	406,804	45,200	10,737–100,000	1104	268 to 2000
5,001 to 10,000	5	41,375	8,275	619,000	123,800	30,000–265,000	1496	558 to 2650
Over 10,000	6	103,791	17,298	1,008,117	168,019	82,000–537,000	971	639 to 1344
	125	263,987	2,112	3,059,348	24,475	400–537,000	$1159	$212 to 5000

* Figures based on conditions in 1916–1917.

CHAPTER XVIII

MILK-PLANT OPERATION

The milk dealer, or middleman, who daily supplies the city dwellers with milk, must purchase the milk from producers located many miles away, often as far as 200 or 300 miles. This milk is collected in the country and shipped direct to the city by rail or truck, or it is brought to the plants in the country by the producers and, after passing through these plants, is shipped to the city.

RECEIVING THE MILK IN THE CITY

In some cities, notably Boston, Mass., the dealer's plant is located on a siding, or spur track. A carload of milk may be switched to the dealer's plant, and unloaded directly on the platform of the plant.

Formerly, when the so-called "leased car" system was in use in Boston, on the arrival of the milk car at the dealer's plant, a large can or "mixer," was placed in the car, and the milk dumped from the car directly into it. This mixer was connected by sanitary pipes to a receiving tank in the plant, and thus a whole carload of milk could be dumped without removing the cans from the car. Owing to the abolition of the "leased car" system, and the consequent decrease in the number of milk cars switched directly to the dealer's plants, and also to the fact that the cans have to be removed from the car in order to be washed, this system has practically disappeared. In the old days, the cans were returned to the farmer without being washed. and so were not removed from the car when the milk was dumped.

In most cities the milk trains are unloaded at the railroad terminals in the city. For the purpose of receiving the milk on the arrival of the trains, large receiving platforms are erected at the railroad terminal. The different dealers have their trucks on hand when the trains arrive, and the milk is transferred from the milk cars to these trucks, and brought to the dealer's plant.

With the increased use of tank cars and tank trucks for transporting milk, large quantities of milk are now unloaded directly from the tanks at the plant.

On arrival of the milk at the city plant it is immediately weighed and transferred to the pasteurizing and bottling departments. Where

milk is received in cans each can of milk must be graded and dumped separately into the weigh can. Where milk is received by tank cars or

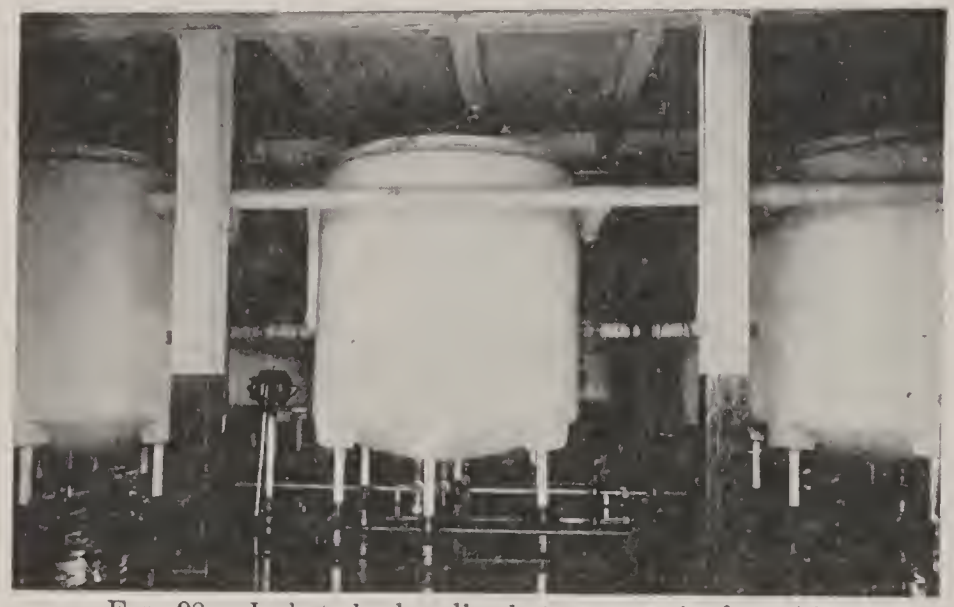


FIG. 99.—Jacketed, glass-lined storage tanks for milk.

tank trucks an entire tank is emptied in a few minutes by gravity pump, or air.

After the milk is weighed, it passes either to a storage tank or directly to the pasteurizer, large plants generally requiring storage tanks.

FIG. 100.—Grading milk by odor on the receiving platform.

In most plants the milk is passed through a clarifier or filter to remove dirt and sediment, before it goes to the pasteurizer.

GRADING, SAMPLING, AND TESTING

Each can of milk must be graded before it is dumped. This is usually done by the sense of smell; the man doing the grading smells

the milk as soon as the lid is removed from the can, and rejects any milk of objectionable odor.

After the milk of each producer is dumped into the weigh can, a sample is taken for chemical analysis. See Chapter IX, " Inspection in the City," for further information regarding testing.

PASTEURIZATION

For information regarding the operation of the pasteurizing plant, see Chapter XX.

BOTTLING AND CAPPING

As soon as the milk is pasteurized and cooled it should be immediately put into clean, sterile, cool bottles. The process of bottling and capping can be carried on at the same time as the pasteurizing process, if a continuous system of pasteurization is used. The capacity of the pasteurizing outfit and the bottle-fillers should therefore be approximately the same and should be such that the work of pasteurizing and bottling, in medium and small plants, may be done in three or four hours. Then the same set of men can be used during the remainder of the day for other work, such as receiving and weighing the milk and washing the bottles and cans. In small plants where one pasteurizing vat is used, two men can dump the milk into the vat as it is received, and as soon as it is pasteurized it may be run over the cooler, the same two men doing the filling and capping.

The filling and capping should be done by automatic machinery. At very small plants it may not be advisable to invest in an automatic filling and capping machine, but such plants should be provided with a small capping device by the use of which the caps do not come in contact with the human hand.

BOTTLE WASHING

Where the old type of in-the-case bottle washer is used, the bottles are washed and then stored in a cool, clean room until they are filled. The continuous system of washing and filling bottles is now, however, quite generally used. With this system a soaker-type bottle washer is used. Various systems of washing and filling bottles are described in Chapter XVII.

Labor Requirements for Washing and Filling Bottles.—The labor required (4) for washing and filling will depend on such factors as:

(1) Method of checking in the bottles from the routes; (2) whether or not the bottles are sorted, and if so, the number of men required;

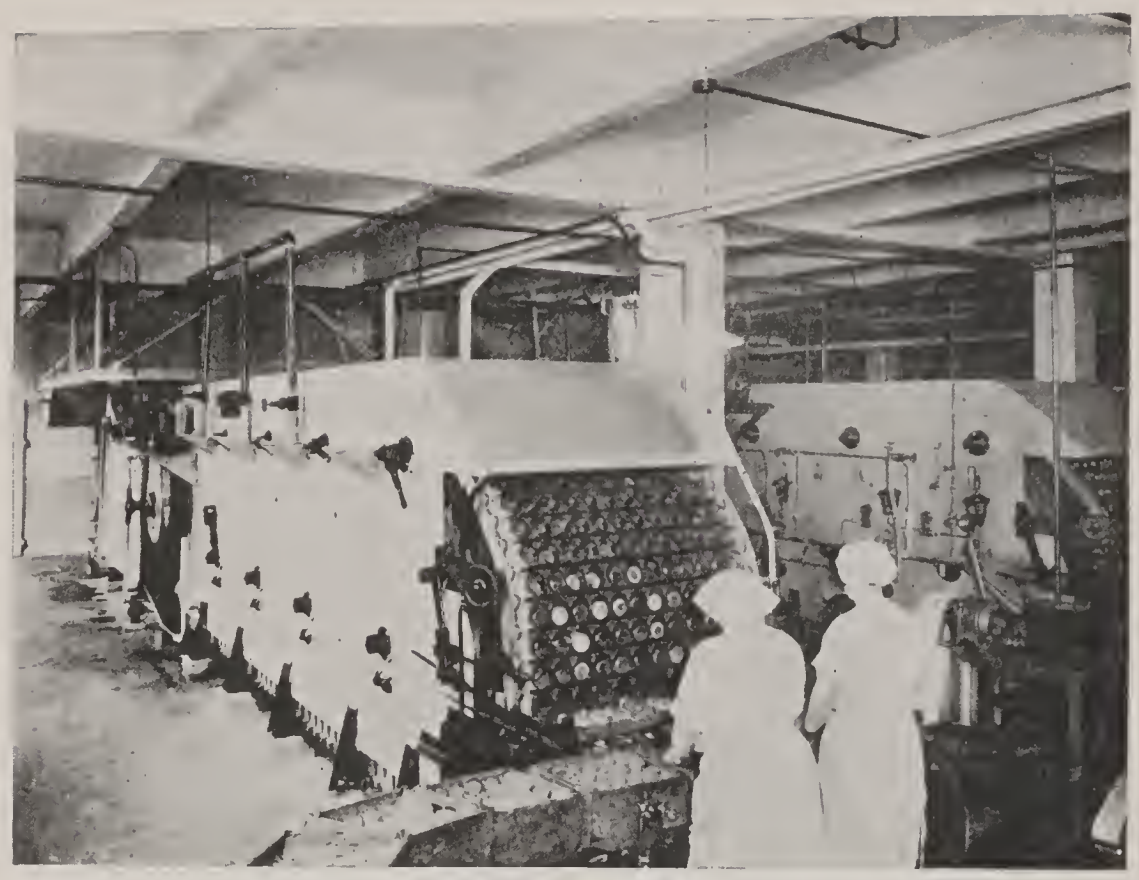


FIG. 101.—Feeding bottles to the washer where the direct system of washing and filling is used. The bottles pass from the washer on conveyors directly to the fillers.

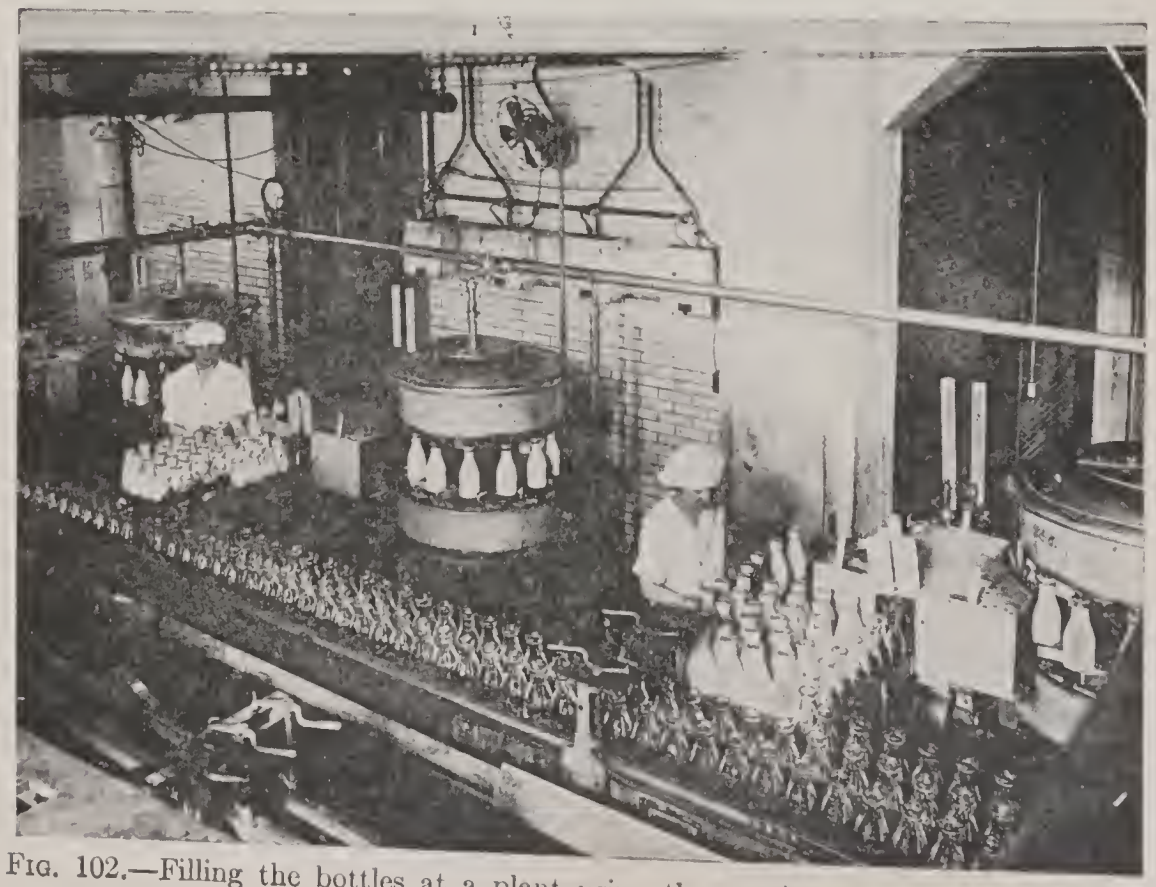


FIG. 102.—Filling the bottles at a plant using the continuous or direct system of washing and filling.

(3) method of getting the bottles from the checking-in platform to the washers, from the washers to the fillers, and from the fillers to the storage room; (4) number and type of machines used; and (5) number of men used for inspection.

Studies made at 171 milk plants showed a great variation in the amount of labor required at plants using different systems of getting the bottles to the fillers. The following three systems were considered:

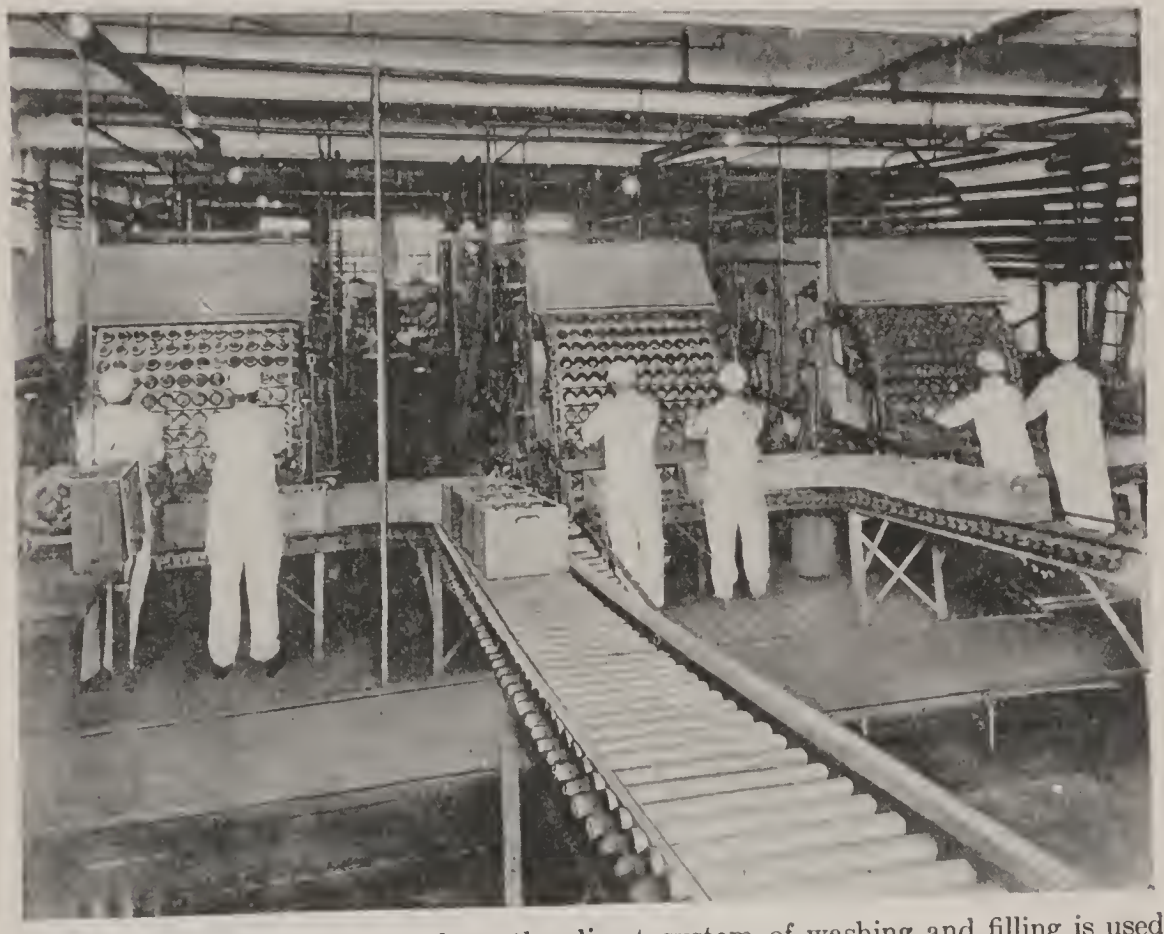


FIG. 103.—Washing bottles where the direct system of washing and filling is used and where system 2 is used in checking in the routes. At eight plants using this combination an average of 8.1 routes was checked in per man-hour and 1204 bottles washed per man-hour.

Direct, indirect, and semidirect. In the direct system (Figs. 101, 102, and 103), no handling of bottles between the washers and fillers is required. After being removed from the cases, the bottles are washed and treated to kill bacteria and are then cooled in the washer, from which they pass automatically on conveyors direct to the fillers. In the indirect system (Fig. 104) the bottles, after being washed in the cases, are stacked either in the bottle-filling room or in a special clean-bottle storage room and allowed to cool, after which they are removed from the cases and fed into the fillers by hand. Thus this system not

only requires considerably more labor in handling bottles than does the direct system, but it offers a greater chance for the bottles to become contaminated, either while in storage or by the hand feeding to the fillers.

Only a few plants use the semidirect system. These plants use the same types of bottle washers as are used with the indirect system

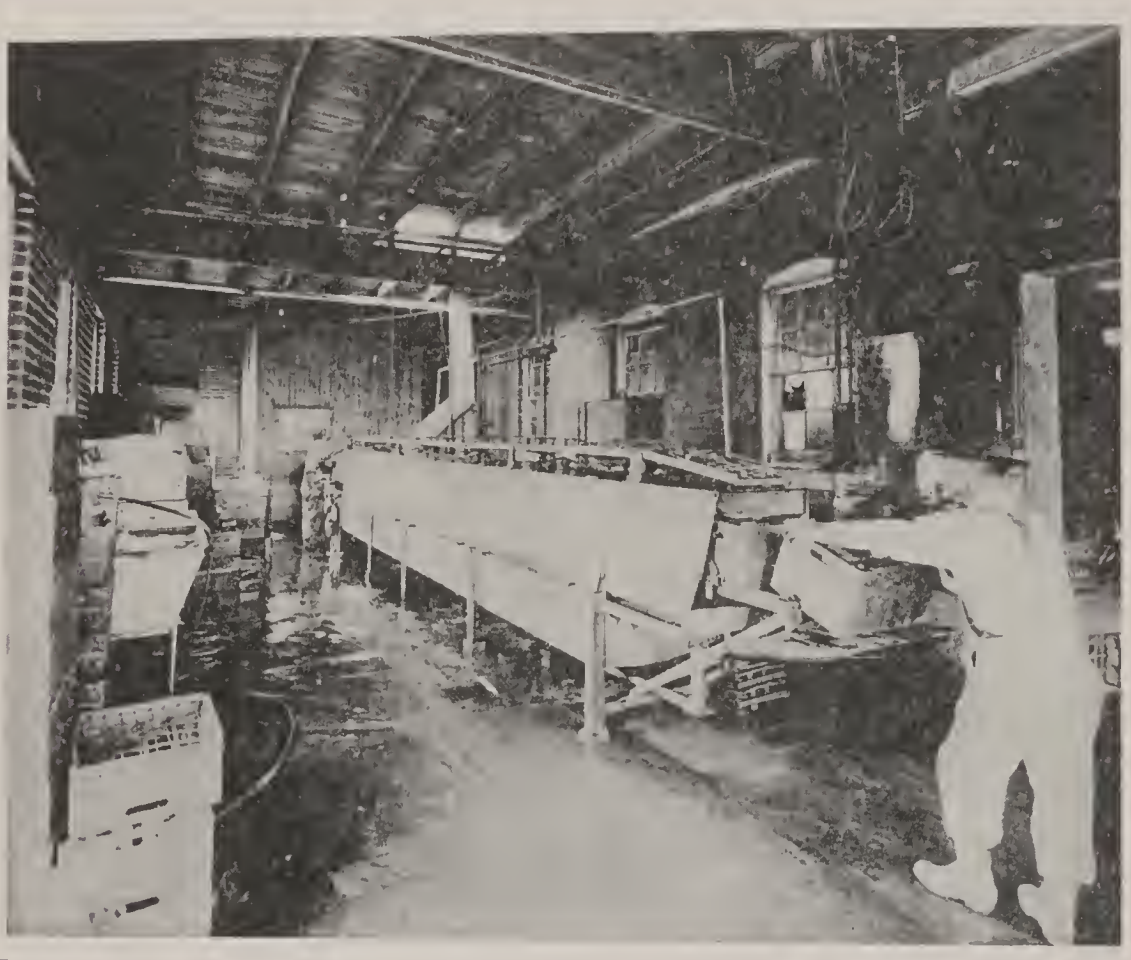


FIG. 104.—Washing bottles at a plant using the indirect system of washing and filling.

except that a cooling arrangement is attached. As soon as the bottles have been washed and sterilized, they are cooled in the cases, after which they pass on conveyors to the fillers, where they are removed from the cases and fed to the machines by hand.

Table 85 shows the importance of the system used in washing and filling the bottles. The average number of bottles washed per man-hour was 748.4 for the 97 plants using the indirect system, 1251.9 for the 6 plants using the semidirect system, and 1016.2 for the 68 plants using the direct system. The number of bottles filled per man-hour was 731.7, 902.5, and 1392, respectively, for the three systems, indirect, semidirect, and direct.

At many plants where the number of bottles washed per man-hour was small, the number filled per man-hour was great, and vice versa.

TABLE 85

COMPARISON OF DIRECT, INDIRECT, AND SEMIDIRECT SYSTEMS OF WASHING AND FILLING BOTTLES AS TO AVERAGE TIME AND LABOR REQUIREMENTS AT 171 MILK PLANTS

System.	Number of Bottles Handled Daily.	Plants. Number.	Washing Bottles.					
			Bottles per Plant. Number.	Men per Plant. Number.	Time Required per Plant.		Per Hour. Number.*	Per Man-hour. Number.†
					Hours*	Man-hours†		
Indirect	5,000 or fewer	8	4,148	1.6	3.9	6.1	1,070	684
	5,001 to 10,000	16	7,231	2.8	3.5	10.2	2,040	707
	10,001 to 15,000	13	11,545	3.7	4.6	17.8	2,502	648
	15,001 to 20,000	14	17,893	3.8	6.6	26.5	2,708	675
	20,001 to 30,000	14	25,258	4.4	6.4	32.4	3,964	780
	30,001 to 50,000	19	40,223	5.4	7.2	45.5	5,578	884
	50,001 to 100,000	13	73,527	12.0	8.0	105.5	9,138	697
Total or average		97	27,043	4.9	5.9	36.1	4,594	748.4
Semidirect	20,001 to 30,000	2	26,667	2.8	6.3	23.4	4,267	1,140
	30,001 to 50,000	4	38,088	3.3	8.4	29.4	4,548	1,297
Total or average		6	34,281	3.1	7.7	27.4	4,471.4	1,251.9
Direct	5,001 to 10,000	5	8,625	1.5	4.3	7.0	2,006	1,232
	10,001 to 15,000	9	12,209	2.0	5.4	10.7	2,242	1,139
	15,001 to 20,000	6	18,323	3.0	6.6	19.4	2,783	944
	20,001 to 30,000	6	24,728	3.0	6.8	20.1	3,663	1,231
	30,001 to 50,000	19	39,611	5.1	7.2	37.4	5,514	1,059
	50,001 to 100,000	14	68,309	9.0	8.4	74.0	8,118	923
	Over 100,000	9	126,894	14.4	8.4	121.6	15,067	1,043
Total or average		68	47,975	6.1	7.1	47.2	6,788	1,016.2

System.	Number of Bottles Handled Daily.	Filling Bottles.						Washing and Filling Bottles.		
		Bottles per Plant. Number.	Men per Plant. Number.	Time Required per Plant.		Per Hour. Number.	Per Man-hour. Number.	Bottles per Plant. Number.	Time Required per Plant. Man-hours	Per Man-hour. Number.
				Hours	Man-hours					
Indirect	5,000 or fewer	3,883	2.1	3.3	7.1	1,172	550	4,015	13.1	306
	5,001 to 10,000	7,160	2.8	4.1	11.3	1,762	636	7,195	21.5	335
	10,001 to 15,000	11,357	3.5	4.7	15.8	2,440	720	11,451	33.6	341
	15,001 to 20,000	17,476	4.6	6.2	27.1	2,817	644	17,684	53.6	330
	20,001 to 30,000	25,105	5.7	6.5	36.6	3,867	686	25,181	69.0	365
	30,001 to 50,000	38,539	7.1	6.8	45.3	5,667	850	39,381	90.8	434
	50,001 to 100,000	72,337	12.9	7.7	100.5	9,451	719	72,932	206.1	354
Total or average		26,412	5.7	5.8	36.1	4,590.6	731.7	26,728	72.2	370.0
Semidirect	20,001 to 30,000	25,167	5.0	6.3	31.5	4,027	799	25,917	54.9	472
	30,001 to 50,000	37,732	5.0	8.0	40.0	4,717	943	37,910	69.4	546
Total or average		33,544	5.0	7.4	37.2	4,522.8	902.5	33,912	64.6	525.4
Direct	5,001 to 10,000	8,604	1.3	4.0	4.8	2,151	1,792	8,614	11.8	730
	10,001 to 15,000	12,000	1.3	6.3	7.1	1,893	1,688	12,104	17.8	679
	15,001 to 20,000	17,956	2.5	7.2	17.3	2,506	1,036	18,140	36.8	494
	20,001 to 30,000	24,470	2.6	7.2	18.6	3,414	1,317	24,599	38.7	636
	30,001 to 50,000	38,834	3.3	7.3	22.4	5,339	1,736	39,222	59.8	656
	50,001 to 100,000	67,628	7.0	8.8	53.9	7,666	1,254	67,969	128.0	531
	Over 100,000	125,814	11.1	9.3	92.4	13,480	1,362	126,354	214.0	590
Total or average		47,390	4.5	7.5	34.0	6,334.9	1,392	47,683	81.3	586.8

*No junk bottles included.

† Includes washing junk bottles.

The average number of bottles washed and filled per man-hour is, therefore, the best indication of the efficiency of the system. The number of bottles washed and filled per man-hour by the indirect, semidirect, and direct systems was 370, 525.4, and 586.8, respectively. The plants using the semidirect system washed, filled, and capped 42 per cent more bottles per man-hour than those using the indirect system. The percentage increase of the direct system over the indirect system was 58. Although no comparison of these systems has been made as to initial cost of machinery, cost of upkeep, or of steam

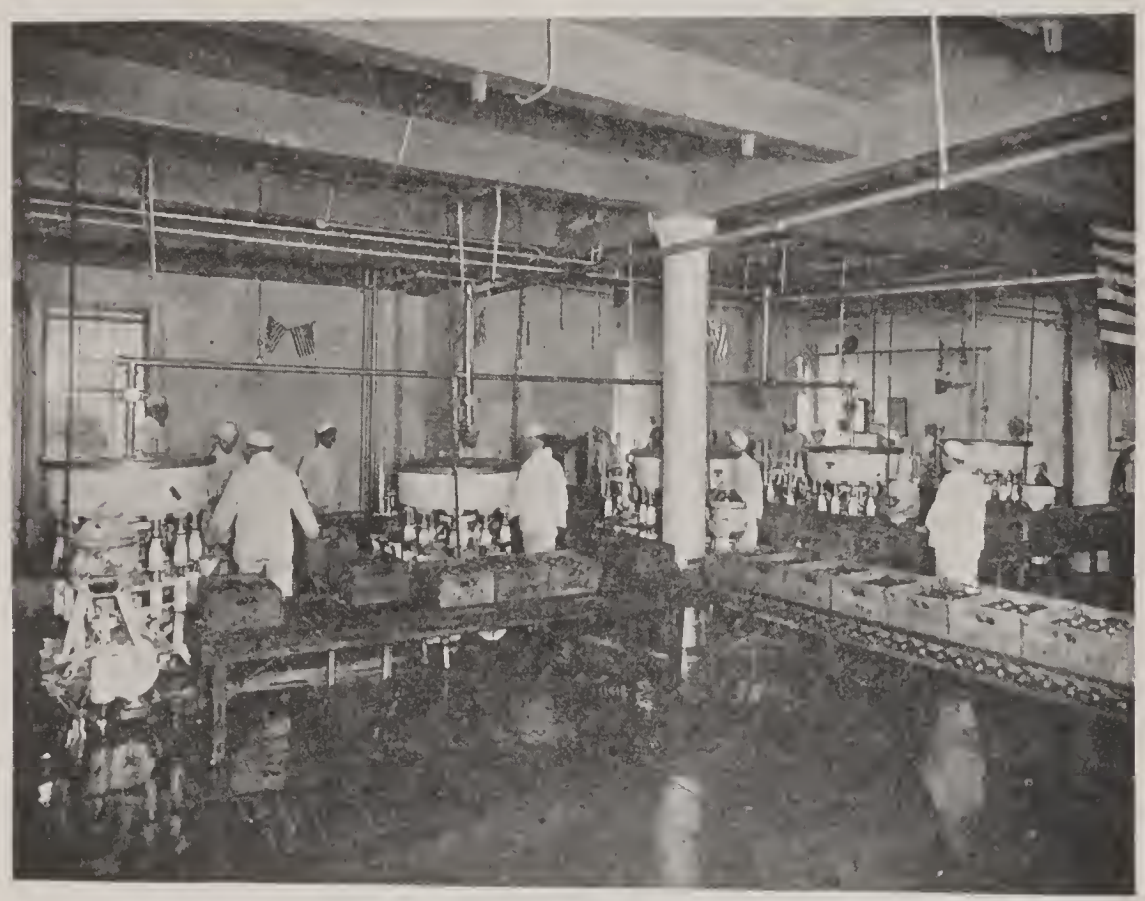


FIG. 105.—Filling bottles at a plant using the indirect system of washing and filling.

and power required to operate the machines, these figures indicate a distinct advantage in favor of the direct system as far as labor is concerned. The trend at the present time is toward the use of this system.

Relation between Number of Floors Used and Man-hour Requirements for Washing and Filling Bottles.—The tendency at the present time is to confine plants to one or two floor levels.[1] Many of the recently constructed plants have one story or one story with a mezzanine floor for the pasteurizing equipment, laboratory, etc. The

[1] See Chapter XVI.

machinery used in the direct system of washing and filling is well adapted to the one-floor plant.

At many plants bottles are washed and filled on the street floor. At some plants, however, more than one floor is used for these operations. The bottles as they are received from the drivers may be sent to the basement or even to the second floor to be washed, and they are then sent up or down, as the case may be, to the street floor to be filled. In some cases bottles are filled on the second floor and are sent to the milk-storage room on the street floor. At all the plants studied in a recent survey the storage room was on the street floor.

Table 86 shows the number of man-hours required per 1000 bottles

TABLE 86

MAN-HOUR REQUIREMENTS FOR 1000 BOTTLES WASHED AND FILLED AT 79 PLANTS USING EITHER ONE FLOOR OR MORE THAN ONE FLOOR FOR WASHING AND FILLING BOTTLES

System.	Plants Using One Floor.		Plants Using More than One Floor.		Difference between (A) and (B).
	Plants. Number.	Time Required. (A) Man-hours.	Plants. Number.	Time Required. (B) Man-hours.	Per Cent.
Direct	32	1.51	11	1.69	11.9
Semidirect	9	1.93	.....	.....	.....
Indirect	21	2.27	6	3.10	36.0
Total or average	62	1.83	17	2.19	20.0

washed and filled at 79 milk plants using either one floor or more than one floor for washing and filling the bottles.

The number of man-hours per 1000 bottles washed and filled was 20 per cent greater for the plants using more than one floor than for the plants using only one floor.

Inspection of Bottles.—It is very important that all bottles be thoroughly inspected after they are washed. Milk delivered in a dirty bottle often means the loss of a customer, besides making the dealer liable from a public health standpoint, and this question of bottle inspection is very important. In large plants inspectors are often so placed that the bottles are inspected as they leave the bottle washer, again before they are filled, and finally after being filled with milk; and even then it is possible for some dirty bottles to get out to the trade.

At one plant a rather unique and satisfactory method of bottle

inspection was used. The inspector at the bottle washer was held responsible for all dirty bottles that he let go through to the filling room. He was paid on a commission basis, as was also the inspector at the filler. For all dirty bottles found by the inspector at the filling machine he was paid a certain premium and the commission of the inspector at the bottle washer was deducted a similar amount. In this way the men took a special interest that no bottles were allowed to pass without careful inspection.

WASHING CANS

The matter of washing cans, though only a small part of the daily milk-plant operations, is a very important one. Many different methods are used at various plants in caring for the cans after the milk is removed from them, and a number of different types of cleaning machines are on the market. The aim of all the efficient ones, however, is thorough cleansing with washing powder and water, followed by rinsing, treatment with steam, and rapid drying. After this the can should be covered and kept from contamination. Some of the largest machines are fitted with powerful pumps, the cans in an inverted position being run through the machine and sprays of washing powder and water, rinse water, hot water, and steam successively forced into them under considerable pressure. They are then dried in the same machine.

Many can washers are so constructed that after the can and cover have been washed, steamed, and dried, the cover is automatically inserted on the can by the machine. The can is returned to an upright position and passes along on a conveyor. In this way much labor is saved.

Very satisfactory results can be obtained at small plants by thoroughly washing the cans by means of a hand brush with water to which washing powder has been added. The cans should then be rinsed and steamed with a jet of live steam for at least forty-five seconds. After steaming, the cans should be allowed to stand for a minute till thoroughly dry, and covers should then be placed on them. It is important that the cans be well dried, and if they are subjected to sufficient steaming they will become dry in a few seconds. Not only does drying leave the can in a better condition as to cleanliness, but it tends to prevent rust and prolong the life of the can. The cover should be thoroughly washed and steamed before being returned to the can.

CLEANING APPARATUS

After each day's run, the whole milk line should be rinsed out by pumping cold or lukewarm water through it. This should be followed by a solution of hot water and washing powder. All parts should be thoroughly scrubbed with brushes and a solution of washing powder, and then thoroughly rinsed and steamed. It will usually be necessary to disconnect all apparatus each day for cleaning.

WASTES INCURRED IN HANDLING MILK IN PLANT

One of the duties of the milk plant operator is to keep the losses in the plant as low as possible. These losses vary considerably at various plants, and considerable saving could be made at many plants if a competent man were in charge.

There are many items that should be borne in mind by the milk plant operator in keeping down losses. Among such items are the following:

1. Avoid milk piping as much as possible, by the proper arrangement of rooms and equipment. Not only is the piping difficult to keep clean, but it causes extra labor. Besides, considerable milk will stick to the pipes at the end of the run, and extra piping will increase the loss of milk.
2. Avoid use of milk pumps wherever possible, by use of gravity flow system. Extra labor is required for cleaning pumps, and the gravity system is more sanitary.
3. Keep a close watch for leaks, spillage, slop, etc., in the milk handling, so as to keep the shrinkage as low as possible.
4. Drain cans well after dumping the milk.
5. Have milk vats so set that they can be readily drained.
6. Keep all joints in milk pipes tight, and thus avoid leaks.
7. Utilize milk returned by drivers, and drain the containers after dumping.
8. Shut down motors or other machinery as soon as through using them, and thus avoid power waste.
9. Avoid extra shafting, pulleys, etc.
10. Avoid extra steam piping by proper arrangement of rooms, and thus avoid losses due to condensation of steam.
11. Keep steam valve and joints well packed to avoid leakage of steam.
12. Keep all machinery well oiled, but avoid waste of oil by careful use and by catching the drip.
13. Avoid water wastes. Save water from cooler coils and from condenser coils whenever possible. Too much water used in washing also requires extra washing powder. Water hose should not be left running when not needed.
14. Utilize exhaust steam, whenever possible, to heat water for use in the plant, also to heat boiler-feed water, and to heat the building.
15. Avoid waste of ice. Leaving ice on cement floors in work room, or exposed to drafts, causes unnecessary waste.
16. Keep doors of refrigerator closed. Do not work in refrigerator more than necessary, and do not leave the lights on.
17. Eliminate breakage of glass as much as possible. Broken bottles at the fillers not only cause the loss of the bottles, but of considerable milk, often much more than a bottleful.
18. Avoid extra labor by convenient arrangement of rooms and equipment, and by use of labor-saving devices, when practicable.
19. Avoid agitation of the milk in handling, as much as possible.

GOODS RETURNED BY ROUTE SALESMAN

Another source of loss and added expense in the milk business is the large quantity of goods returned from delivery routes and the uneconomical disposition made of the returned goods. Some dealers make a special effort to keep the returns as low as possible, while others do not, probably figuring that it is cheaper to have large returns now and then, than to take the risk of having the driver run short and being obliged to send out extra goods by special delivery. It is to the dealer's advantage to keep the returns as low as possible and at the same time properly take care of the trade.

The figures in Table 87 were obtained from a dealer running about twenty-five routes, and show the quantities of the various goods returned, expressed as a percentage of those taken out.

TABLE 87

Quantities of Various Goods Returned at a Representative Plant with Twenty-five Routes, in Percentage of Goods Taken Out (1)

	Total for Year. Per Cent Returned.	Month of October. Per Cent Returned.	Monday in October. Per Cent Returned.
Gallons of milk (bulk)	5.0	2.0	4.5
Quarts of milk	4.3	4.0	4.5
Pints of milk	5.2	6.0	7.5
Half pints of milk	3.1	4.0	7.0
Quarts certified milk	6.4	6.0	6.2
Quarts buttermilk	20.0	22.0	26.0
Gallons cream	6.6	10.0	12.0
Quarts cream	4.0	3.0	6.5
Pints cream	16.0	16.0	20.0
Half pints cream	8.8	9.0	11.0
Half pints whipping cream	25.0	23.0	23.2

Among the most common methods of disposing of returned goods are the following:

1. Sell the same day as cash sales at the plant or for special orders.
2. Sell to peddlers the same day.
3. Sell on the wholesale routes the next day.
4. Sell on the retail routes the next day.
5. Separate and sell the cream to the trade the next day.
6. Separate and sell cream to ice-cream dealers or butter stores, or dispose of it at the butter, ice-cream, and cheese department of own plant.

7. Sell sour cream to certain classes of trade for family use.
8. Sell sour milk to cottage-cheese dealers.
9. Use in the manufacture of casein, milk sugar, albumen, etc.
10. Use in the manufacture of buttermilk.

Each dealer has to study his own conditions, for what may be the best way for one dealer to dispose of returned goods may not be suitable for another. The majority of dealers seem to favor the method of dumping all returns and disposing of the cream for butter and ice-cream purposes. A second grade of buttermilk obtained by making butter from this cream can also be disposed of to bakeries, etc. In this way the returns are handled at small expense and the danger of old milk going out to the trade from this source is eliminated.

Among the methods used to keep the returned goods as low as possible are the following:

1. Use the quantity of goods returned by the route salesman as one of the points on which the driver's commission is based.
2. Give prizes of different amounts each month to drivers who return the least during the month.
3. Require drivers to pay at the rate of one cent per bottle for all milk returned above 6 per cent of that taken out.

SHRINKAGE IN HANDLING MILK

The shrinkage of milk in handling is an important item, and every effort should be made to keep it as low as possible. Table 88 gives the shrinkage for a series of days at three plants.

At one small plant, where the milk was received by weight and pasteurized in a vat, the loss in pasteurizing and bottling was as follows:

Milk received, 1254 pounds.....	583	quarts	
Received from filler.....	572	"	
Shrinkage.....	11	"	or 1.9 per cent

As the milk was received by weight, this loss was nearly all due to carelessness. By taking special care for one day, the plant operator was able to reduce the shrinkage to .53 per cent. This was the actual loss in pasteurizing and bottling when the milk was handled carefully.

Causes of Shrinkage.—Losses from shrinkage, as reported by 115 dealers, varied from 0.3 per cent to 7.0 per cent, and the average was 2.29 per cent. Such losses are largely due to the following causes:

1. Leaky cans.
2. Dented or battered cans.
3. Cans not full.

4. Careless handling of cans, in transferring from cars and dumping.
5. Inefficient draining of cans.
6. Leaky or battered apparatus.
7. Fillers out of repair, and leaky valves.
8. Losses at the filler. This may be caused by the valves not being properly adjusted, carelessness in handling, breakage of bottles, etc.
10. Loss from milk left in the pasteurizer, pipes, pumps, tanks, or other apparatus.
11. Loss from process of pasteurizing, separating, homogenizing, and clarifying, by evaporation and mechanical losses.
12. Loss by transferring milk and cream from bottles to cans, as in the case of returns from the routes.
13. Shrinkage in cooling milk.

TABLE 88

SHRINKAGE OF MILK AT CITY PLANTS (1)

PLANT NO. 1

Daily Receipts at Plant. Gallons.	Quantity Bottled. Gallons.	Daily Loss. Gallons.	Loss. Per Cent.
1221	1184	37	3.0
1000	976	24	2.4
1200	1162	38	3.2
1100	1071	29	2.6
Average 1130	1098	32	2.8

PLANT NO. 2

1324	1299	25	1.9
1295	1274	21	1.6
1492	1468	24	1.6
1395	1385	10	0.7
Average 1376	1356	20	1.4

PLANT NO. 3

1049	1004	45	4.3
1021	979	42	4.1
1087	1046	41	3.8
Average 1052	1009	42.6	4.1

There is necessarily a certain amount of shrinkage in transferring milk from cans to bottles and in the process of clarifying and pasteurizing. Special attention to this matter, however, should reduce these losses considerably. Collecting pans should be placed under all milk apparatus where milk is apt to spill, to catch all drip, and especially under the filling machines.

FIG. 106.—Weighing and sampling milk. One man records the weights.

CHECKING SYSTEM FOR SMALL PLANT

All milk plants, whether large or small, should have some sort of an accounting system. Medium-sized and large plants usually have an elaborate system of accounting, which would not be necessary or practicable for a small plant because of the large amount of work and detail required. On the following pages are given some of the forms that may be used at small plants. No attempt is made to go into the general bookkeeping system.

Checking Goods Handled in the Plant.—It is well known by most milk dealers that there is a considerable shrinkage, as well as other loss, in handling milk at the city plant. Among these losses are those from pasteurizing, bottling, filling cans from bottles of milk returned from routes, leakage, breakage, spillage, etc. Many of these "known losses" can be determined with fair accuracy, and an attempt should be made to ascertain just what they amount to each day.

There are, however, other losses connected with a milk plant that are sometimes overlooked. For example, a certain driver may go out with more milk than is charged to him, or he may receive credit for

returning more milk than he actually returns, or a quantity of milk may be sent out "special delivery" and fail to be charged. In order to check up such losses as these some sort of balance of all the goods handled at the plant should be made out each day. Fig. 107 is a stock balance sheet that is adaptable for a small dealer operating from five to ten wagons.

At some plants, the keeping of such a record will eliminate many unnecessary losses, and will enable the plant superintendent to know

Daily Balance of Stock _____ 19 _____

	MILK				CREAM				B.M.	SKIM	BUTTER	EGGS		VALUE OF		TICKETS
	POUNDS	GALS.	QUARTS	PINTS	LBS.	QUARTS	PINTS	HALF PTS.	GALS.	GALS.	LBS.	DOZ.		LOAD		
On hand 6 p.m. Previous Day																
Received from Producers																
Manufactured																
Total																
Sales Route No 1																
Sales Route No.2																
Sales Route No.3																
Sales Route No.4																
Sales Route No.5																
Sales Route No.6																
Plant Sales																
Special Deliveries																
Manufactured																
Separated																
Spilled																
Broken																
TOTAL																
On Hand 6 P.M.																
Total																
Over																
Short																

FIG. 107.—Form for daily checking of product that passes through the milk plant.

each day just how he stands. A monthly balance sheet similar to this may also be used each month as a check on the losses for the month.

Checking the Shipping and Receiving Clerks.—At some plants it is important that the man who ships out the goods to the drivers and the one who receives the returns from them should account for all goods handled or received. Fig. 109 is an example of a form that might be used to check the receiving clerk, and Fig. 108, one that might be used to check the shipping clerk.

DATE_____

BALANCE OF SHIPPER

	MILK			CREAM				BUTTERMILK		SKIM		BUTTER
	Gals.	Qts.	Pts.	Gals.	Qts.	Pts.	½ Pts.	Gals.	Qts.	Gals.	Qts	Lbs.
On Hand 3 P. M.												
Delivered to Route 1												
" " 2												
" " 3												
" " 4												
" " 5												
" " 6												
Cash Sales												
Broken and Spilled												
On Hand 7 A.M.												
Total												
Over												
Short												

FIG. 108.—Form for balancing the shipping clerk.

BALANCE OF RECEIVING CLERK

Form E

	Milk			Cream			Butter, Cheese	
	cans	qts.	pts.	gals.	pts.	½ pts.	Lbs.	or Packages
Returns of Route #1								
" " " #2								
" " " #3, etc								
Total								
Amount turned in to Creamery								
Over								
Short								

FIG. 109.—Form for checking the man who receives the route returns.

MILK COOLER REPORT

The form shown in Fig. 110 could be used to balance the milk cooler or milk-storage room during the day. To the cooler are charged all goods on hand in the morning and all receipts. Credits are made for the disposal of goods to various departments during the day. It would of course be necessary to be able to determine approximately the exact amount of goods that are turned over to the pasteurizer, separator, etc. It would also be desirable to have additional forms to balance the

MILK COOLER REPORT

	Milk.					Cert.	Spe. Milk.		B. M.		Cream				XX Cream.			
	Gallons	Quarts	Pints	½ Pints	⅓ Quarts	Quarts	Quarts	Pints	Gallons	Quarts	Gallons	Quarts	Pints	½ Pints	Gallons	Quarts	Pints	½ Pints
Receipts:																		
In storage 8 A.M.																		
Received from producers																		
Returned from routes																		
Converted																		
Total																		
Disbursements:																		
To pasteurizer																		
To separator																		
To standardizing cream																		
Converted																		
To retail routes																		
To wholesale routes																		
To spec. del. routes																		
To office sales																		
To known losses																		
In storage 6 P.M.																		
Total																		
Over																		
Short																		

FIG. 110.—Form for balancing milk cooler.

pasteurizing and separating departments. Under "known losses" would be entered shortages that were found in the balance of the separating and pasteurizing departments; also milk spilled, drunk by employees, etc. The pasteurizing department, for example, would be charged with the milk and cream delivered to it and credited with the amount of bottled and bulk goods turned over by it to the cooler. Likewise the separator would be charged with all milk turned over to it and credited with the cream and skim milk manufactured. The shortages in these two departments would be entered under "known losses" in the milk cooler report.

An inventory of stock must be taken by the night man, and this will be checked by the day cooler man when he takes charge in the morning. He will take an inventory at 6 P.M., which will be checked by the night man when he takes over the cooler at night.

NUMBER OF MEN REQUIRED TO OPERATE A MILK PLANT

The number of men required to operate a milk plant depends, to a large degree, on the plant arrangement and types of equipment used. Table 89 shows the relation between the size of plant and the num-

TABLE 89

RELATION BETWEEN THE SIZE OF PLANT AND LABOR REQUIREMENTS (4)

Group.	Plants. Number.	Milk and Cream Handled Daily per Plant. Quantity. Gallons.	Average. Gallons.	Bottled. Per Cent.	Total Men per Plant.* Number.	Milk and Cream Handled per Man. Total. Gallons.	Bottled. Gallons.
1	13	2,000 or less...	1,407	81.0	6.8	208	169
2	21	2,001 to 5,000..	3,308	88.2	15.3	216	194
3	34	5,001 to 10,000	7,342	85.1	34.5	213	181
4	9	10,001 to 15,000	11,504	82.0	46.0	249	205
5	8	15,001 to 20,000	17,393	87.0	78.6	221	192
6	7	Over 20,000....	27,448	88.0	103.0	267	235

Group.	Special Help Employed. Relief Men. Number.	Checkers. Number.	Engineers and Maintenance Men.† Number.	Miscellaneous Men.‡ Number.	Help Employed per 1000 Gallons Milk and Cream Handled. Total Men. Number.	Relief Men. Number.	Checkers. Number.	Engineers and Maintenance. Men. Number.	Miscellaneous Men. Number.
1	0.3	0.9	0.5	0.5	4.808	0.219	0.629	0.383	0.328
2	1.1	2.2	1.4	1.1	4.618	.317	.669	.425	.331
3	2.2	6.7	3.4	2.3	4.704	.305	.906	.457	.309
4	1.9	7.3	5.0	5.8	4.015	.164	.637	.434	.502
5	6.9	13.4	8.9	5.5	4.522	.395	.769	.510	.316
6	6.0	13.4	8.7	9.3	3.753	.219	.489	.318	.338

* Including all men whose time was chargeable to the market-milk department. If they were used in other departments also, time was prorated. Clerks and bookkeepers were not included.

† Employees who were engaged in the repair and upkeep of equipment and whose time was chargeable to the market-milk department.

‡ Such as foremen, janitors, and elevator men.

ber of men required at 92 plants, grouped according to number of gallons of milk and cream handled daily. As a rule, there is an increase in the number of gallons handled per man as the size of the plant increases. In small plants it is usually necessary to shift a man from one job to another, whereas in large plants one man often is on the same operation for the full day. This specialization of labor naturally effects economies in operation. At large plants, however, on account of this very fact of specialization, more supervision is required, and more special and miscellaneous men are used, so that the difference in the number of gallons handled per man at the large and small plants is not so great as might be expected. This difference is somewhat greater, however, when bottled milk alone is considered.

Table 89 shows two exceptions to the rule that the number of gallons of milk and cream handled per man increases as the size of the plant increases. These exceptions are the plants in Groups 3 and 5. They can in part be explained by the fact that there were no one-story plants in Group 5 and only 6 out of a total of 34 in Group 3. As is shown on pages 245 and 310, less labor is usually required to operate one-story plants.

The table shows no relation between the number of relief men used per 1000 gallons handled and the size of the plant, as the number is dependent largely on the practices followed in the city where the milk plant is located. In some cities no relief men are required, as all the men work a full week of seven days. In others, the men work only six days per week so that an extra man is required for each six men. There is also very little relation between the size of plant and the number of checkers used per 1000 gallons of milk and cream handled as this is determined primarily by the system of checking routes in and out. The table shows that, although the number of miscellaneous men employed increases with the size of the plant, the number of these men per 1000 gallons of milk and cream handled is fairly uniform for plants of all sizes except Group 4, in which it is higher than in the other groups. The fact that this group contained only plants of more than one story is the principal reason for the large number of miscellaneous men.

SURPLUS MILK

Utilization of Surplus Milk.—Each milk-plant operator must determine for himself how to dispose of his surplus to the best advantage, in his particular locality. Market demands and prices are, of course, the impor-

tant factors in deciding what products can be most advantageously manufactured from the milk that cannot be disposed of at market milk prices.

The following calculations illustrate how the returns may be figured, on various products that can be made from surplus milk.(1) The values here attached to the various products are arbitrary, and the actual price will, of course, depend to a great extent, on the particular locality. The following arbitrary values are used:

Butter	50 cents a pound
Buttermilk	20 cents a gallon
Cottage cheese	5 cents a pound
Sweet cream	$1.50 a gallon

Value of by-products from 100 pounds of surplus milk, at assumed prices.

Butter, Cottage Cheese, and Buttermilk.

The cream from 100 pounds of 4 per cent milk will make approximately 4.75 pounds of butter, at 50 cents	$2.38
and 1 gallon of buttermilk, at 20 cents	.20
The skim milk will produce approximately 9 pounds of cottage cheese, at 5 cents	.45
	$3.03

Sweet Cream and Cottage Cheese.

100 pounds of 4 per cent milk will make approximately 2.5 gallons of 20 per cent cream, at $1.50	$3.75
and approximately 8.75 pounds of cottage cheese, at 5 cents	.44
	$4.19

Butter and Buttermilk.

100 pounds of 4 per cent milk will make approximately 4.75 pounds of butter, at $0.50	$2.38
and approximately 10 gallons of buttermilk, at 20 cents	2.00
	$4.38

Sweet Cream and Artificial Buttermilk.

100 pounds of 4 per cent milk will make approximately 2.5 gallons of 20 per cent cream, at $1.50	$3.75
and approximately 9 gallons of artificial buttermilk, at 20 cents	1.80
	$5.55

Thus, with the prices given, it would be more profitable for the dealer to separate the surplus, sell the sweet cream and make buttermilk from

the skim milk. As stated, however, these figures are given merely for illustration; the cost of manufacture, market demand, and the prices that can be procured for the products must be considered in each case. Such illustrations will assist a dealer in determining what prices he can afford to charge for certain products, as compared with prices of other products, as well as in determining what products he can most advantageously make from his surplus milk.

The question of paying for milk that cannot be disposed of as market milk, but which must be manufactured into by-products, has received the attention of dealers, economists, health officials, and others in recent years; and, in many cities, systems have been worked out whereby the producer receives, for milk which is manufactured into by-products, a price based on the value of these by-products. In this way the middleman handles all the milk the producer provides and pays for it a price based on his own net returns. Such a system seems more equitable to all parties concerned than the old system of trying to make the price for all milk received as low as the producer would take and as high as the dealer would give.

Manufacture of By-products.—A milk-plant operator should be familiar with the manufacture of the ordinary by-products: butter, cottage cheese, and buttermilk.

Butter.—For detailed information as to butter making, operators are referred to Farmers' Bulletin No. 876 and standard books on the subject.

Cottage Cheese.—For directions on the manufacture of cottage cheese, reference should be made to U. S. Department of Agriculture Bulletin No. 576, "The Manufacture of Cottage Cheese in Creameries and Milk Plants."

Buttermilk and Artificial Buttermilk.—One of the most economical ways of disposing of surplus skim milk or sour milk is by the manufacture and sale of buttermilk or of artificial buttermilk. Many physicians recommend buttermilk for dyspepsia and for other ailments of the digestive system. It is a favorite beverage with many people, and is without doubt superior to many other drinks served at soda fountains. It is sold in large quantities for cooking purposes to the family trade, as well as to bakeries, restaurants, etc. A good profit can be made by the sale of buttermilk, and efforts should be made to increase the sales of this product. Perhaps one of the reasons that some dealers do not handle the so-called commercial product is that they do not know how to make it. It takes practice and experience to be able to obtain a uniformly good product.

Rogers and Albus (3) recommend the following method of manufacture of cultured buttermilk:

"In making cultured buttermilk from milk the same procedure should be followed as in making a starter for cream ripening. A good, clean-flavored mother starter should be carried along with every possible precaution to prevent contamination. Good commercial cultures can be obtained, but if it is not convenient to use one of these a natural starter should be prepared. For this purpose the following procedure may be followed:

"Milk should be selected from several sources. About 1 pint of each lot of milk is put into clean glass jars or bottles and allowed to stand in a warm place until the milk has curdled.

"When this occurs about 1 pint of milk is put into each of an equal number of bottles and held in steam or boiling water for one-half hour, after which it is cooled.

"About 1 teaspoonful of milk is transferred from each of the bottles of sour milk to one of the bottles of heated and cooled milk.

"These samples are allowed to curdle and the process is repeated until one sample is obtained which curdles in at least 8 or 10 hours with a smooth curd free from whey and gas bubbles and with a pleasant acid taste. Gas bubbles or the separation from the curd of a milky or straw-colored whey show that the lactic-acid bacteria are still mixed with other kinds of bacteria. Considerable variation in flavor can be found in different cultures, and care should be exercised to select one that gives a clean, sharp taste.

"This culture is propagated in the same way from day to day. The amount of this mother starter which should be carried will depend somewhat on the quantity of cultured buttermilk to be made. One quart should be enough for 20 to 30 gallons.

"(*a*) The mother starter is added to the milk to be used for cultured buttermilk, or (*b*) the milk is pasteurized in a continuous pasteurizer at 180° to 185° F. (82° to 85° C.), or preferably it is held in water-jacketed vats or cans at 180° F. (82° C.) for 30 minutes to an hour; cooled to about 70° F. (21.1° C.); and the mother starter added. The most desirable temperature for this fermentation is 70° to 75° F. (21.1° to 24° C.).

"When this milk has curdled, it is cooled at once to about 50° F. and churned thoroughly to break the curd into fine particles.

"The cultured buttermilk should be smooth, free from lumps, and show a separation of whey and curd only on long standing.

"Milk to be used for making cultured buttermilk should be fresh and clean flavored. Good cultured buttermilk can not be made from milk that is tainted or too old to be used for other purposes. Skim milk, partly skimmed milk, or whole milk, as desired, may be used.

"A more nearly uniform product is obtained if the milk is pasteurized. The scorched taste which results from pasteurization at a high temperature is not objectionable as it is obscured by the acidity of the sour milk. The time of the inoculation may be arranged to suit the convenience of the maker and can be determined by experience in each

case. By using the same culture and holding the temperature uniform, the amount of the starter can be adjusted to bring the acidity to the curdling point at any definite time within narrow limits. The temperature of the milk should be between 21° and 24° C. (70° to 75° F.). More rapid development of acid can be obtained at higher temperatures, but at the lower temperatures the lactic-acid bacteria are more successful in checking the growth of digesting and gas-forming bacteria. At lower temperatures and with a slower development of acid the casein is precipitated in a finer and more friable curd than at temperatures inducing a more rapid acid production. As soon as a fine curd has been formed the milk should be cooled promptly to below 50° F. to prevent the contraction and toughening of the curd."

These authors (3) have the following to say regarding the procedure to be followed in making a starter:

"Careful butter makers build up starters from commercial cultures sold in the form of powders, tablets, or fluid cultures, as varieties of lactic-acid bacteria selected with special reference to the production of a desirable flavor in butter. The butter maker puts this culture into about a quart of milk which has been steamed for an hour or more to reduce the bacteria to the lowest possible number. After standing overnight the milk will usually be curdled, but gas bubbles and other evidences of contamination may be observed. A small portion of this milk is transferred to another bottle of milk prepared as before, and this process is continued until the acid fermentation has become sufficiently active to eliminate the contaminating bacteria and the milk curdles with a clean, acid taste and without signs of gas or the separation of a watery whey. This small starter, called 'mother starter,' is carried along indefinitely by daily transfers to freshly steamed milk. If reasonable precautions are taken to prevent contamination after a thorough heating of the milk, this culture will remain pure and vigorous for an indefinite time.

"To prepare the starter actually used in ripening the cream, a larger lot of milk—25 to 50 gallons or more, according to the amount of cream—is heated for an hour or more. This is usually done in a special apparatus (sold by creamery supply houses) which consists of a large can inclosed on the sides and bottom by a steam jacket and fitted with a belt-driven stirrer. Milk either skimmed or unskimmed is heated by turning steam into the jacket; during the heating the milk is stirred constantly. After the pasteurization is completed cold water is run into the jacket and the milk is cooled to about 24° to 27° C. (75.2° to 80.6° F.). A bottle of the mother starter is added and the can is covered and allowed to stand overnight. This gives a large and active pure culture of lactic-acid bacteria to start the acid formation in the cream. Better results are obtained if the cream is first pasteurized."

REFERENCES

(1) Clement, C. E., Milk Plant Operation. U. S. Dept. Agri. Bul. 973, 1923.
(2) Milk Plant Letters. U. S. Dept. Agri. Bur. of Dairy Ind.
(3) Rogers, L. A., and Albus, W. R., Fermented Milks. U. S. Dept. Agri. Bul. 319.
(4) Clement, C. E., Le Fevre, P. E., Bain, J. B., and Grant, F. M., Effect of Milk Plant Arrangement and Methods of Operation on Labor Requirements. U. S. Dept. Agri. Tech. Bul. 153, 1929.
Mortensen, Martin. Management of Dairy Plants, 1921.
Parker, H. N., The City Milk Supply. McGraw-Hill Book Co., 1917.

CHAPTER XIX

PASTEURIZATION OF MILK

EARLY HISTORY

It was through the troubles of a poor wine maker that Louis Pasteur of France began his researches on the effect of heat in checking the fermentations in wine, which studies were later extended to milk and led to pasteurization. From 1857 to 1862 Pasteur worked with both wine and milk and found that bacteria could be killed by heat. Pasteur's first experiments were carried on at relatively high temperatures, but in August, 1865, he announced to the Academy of Science that maintaining wine for a few minutes at 140° to 158° F. kept it from spoiling. This was the first real work in pasteurization or heating the product to a relatively low temperature. Previous work might properly be classed under the heading of sterilization.

Jacobi of New York, in 1875, seems to have been one of the first to recognize the public health aspects of pasteurization and advised the use of heating milk for infant feeding. In 1886 the German scientist Soxhlet continued experiments in pasteurization and devised the first small home-made sterilizer. Even then the temperatures used for so-called pasteurization were much higher than those used at present. Dr. Rowland G. Freeman of New York was probably the first man to make practical application of lower temperatures maintained for longer times in connection with the treatment of milk for infant feeding. He was convinced that the previous high temperatures were unnecessary and advocated a temperature of 158° F. maintained for twenty minutes. It was in 1893, however, that the first large demonstration of pasteurizing milk for infants was accomplished by Nathan Straus, when he established his first milk depot in New York City. From June to November of that year he distributed over 34,000 bottles of pasteurized milk from his infant milk depot.

Up to and including this date pasteurization had not entered the commercial field to any great extent in this country, although work had been going on in foreign countries along commercial lines, using for the most part relatively high temperatures.

According to available statistics the first commercial pasteurizer was made in Germany in 1880 by a man named Ablbom. Work was also go-

ing ahead in Denmark with commercial pasteurization. In this country one dealer pasteurized milk for infants as early as 1893, but according to Parker real commercial pasteurization started in Cincinnati in 1897, in New York in 1898, in Philadelphia in 1899, in St. Louis in 1900, in Milwaukee in 1903, and in Boston and Chicago in 1908. It was not until 1904 that any appreciable amount of the general milk supply was pasteurized.

Among the pioneers in developing systems of pasteurization and pasteurizing equipment may be mentioned Reid of Philadelphia; Joseph Willman of Derby, Conn.; Professors Farrington and Russell of Wisconsin; S. M. Heulings; Schier of Baltimore; Park and Horton of New York.

One of the earliest, if not the earliest, experiments in pasteurization was made in 1895 by Heulings in cooperation with Professor Wing of Cornell. Heulings devised an apparatus for heating and holding milk which consisted of a series of tank holders. This machine was built by D. H. Burrell & Company. The Potts pasteurizer was used for pasteurizing milk and cream in Wisconsin during the years 1898 and 1899. It consisted of a wooden barrel revolving with an agitator and a heating jacket. It is probable that the present-day pasteurizing vat is a development from this idea. At about the same time the Russell pasteurizer was also in use.

One of the earlier milk heaters was the Farrington pasteurizer, in which revolving disks contained the heating medium. The earlier vats manufactured by the Creamery Package Manufacturing Company also contained disks and were probably a development of the old Farrington heater.

An interesting development in connection with pasteurization was effected by Willman about 1904 when he brought out the regenerative pasteurizer. The milk was heated over a drum, and the apparatus was so arranged that the heated milk would transfer some of its heat to the cold raw milk coming in. About 1908 Willman introduced the double tube regenerative apparatus for heating and cooling milk. This consisted of several small tubes inclosed in a larger pipe. The incoming raw milk was heated by the hot milk coming from the pasteurizer or holder. It is interesting to note that the A. H. Reid Company hold a patent issued in January, 1907, covering a regenerative system of pasteurization. In the Reid system the incoming cold milk passed through the inside of a surface-tubular cooler, while the hot pasteurized milk flowed over the outside. In this way the hot pasteurized milk heated the incoming raw milk, while being itself cooled down by the colder milk.

One of the most important steps in pasteurization was the introduction, in 1906, by Mr. Willman of the pocket-type holder. He set up his first commercial apparatus of this type at the Sheffield Farms Company's Fifty-seventh Street plant in New York City in 1907. In this type milk from the heater goes to a compartment in the holder and, after being held for the required length of time, passes out through a valve to the cooler. This is believed to be the real beginning of modern holding pasteurization at comparatively low temperatures.

It is stated that the first coil vat was designed and patented by the J. G. Cherry Company in 1907. At that time the equipment was used for cooling and ripening cream only, and it was about 1911 before the coil vat was used as a batch milk pasteurizer in Cincinnati. Other companies have put out coil vats somewhat similar to this one.

About the year 1909 the barrel heater was first developed, but it did not come into general use until 1912 or 1913. In this type of heater the milk passes through pipes around which is the heating medium. The heating medium usually has a much higher temperature than that to which the milk is heated, and the milk passes through quite rapidly.

The D. H. Burrell Company was apparently the first to use the internal-tube heater for pasteurizing milk. This system consists of a pipe within a pipe. The milk goes through the inner pipe and the heating medium passes around it in the outer pipe. The first installation of this apparatus was at the Queen City Dairy Company, Buffalo, N. Y., in 1910. The double tube of Willman preceded this, but his machine was used as a regenerative cooler rather than as a pasteurizer. Burrell also put out an internal-tube retarder and cooler on the same principle at about the same time. It was about this same date that Dr. Wm. H. Park of New York suggested the use of a series of upright vertical tanks through which heated milk passed for the purpose of retarding the flow and maintaining the milk for a greater length of time in its heated condition.

Another interesting feature in connection with heating milk has been the various experiments in the electrical treatment of milk which have extended over a period of fifteen or twenty years, including a number of commercial installations of various types.

These are believed to be the pioneer steps in the development of heating, pasteurizing, and holding milk commercially in this country. Many modifications of these systems have subsequently been made and some new ideas have been incorporated. The later developments which warrant interest are the glass-lined holding tanks, the Burrell spray vat, and the Mortensen type of pocket holder, which is intended

to prevent leakage of unpasteurized milk to the cooler or its mixture with milk which has been pasteurized for the full length of time.

HOLDING PROCESS OF PASTEURIZATION

The "holding process" consists of heating the milk to 142° to 145° F. and holding it at that temperature for thirty minutes; the "flash system" consists of heating the milk for an instant to 155° to 165° F. Investigators found that all pathogenic organisms that may occur in milk, as well as a large proportion of other organisms, are killed by a temperature of 142° to 145° F., maintained for thirty minutes, so that not only is the milk made safe for human consumption by this process but the keeping quality is improved as well.

OPPOSITION TO THE PROCESS

At first there was considerable opposition on the part of the public, and in many cases on the part of health officials, to pasteurized milk; and even now some health officials do not advocate its use. It can be stated, however, without the likelihood of severe criticism, that pasteuriziation of milk, when properly performed, is now generally recognized as essential to public health. About the only practical argument now raised against pasteurization is that it is not always properly done; while this is perfectly true, it is no reason for condemning the process.

PHYSICAL CHANGES PRODUCED BY PASTEURIZATION

One of the objections that have been raised against pasteurized milk is that the cream line in the milk is injured by the process. Whether or not the cream layer is reduced depends a good deal on how the process is performed. Judkins and Downs (1) carried on some experiments to show what effect, if any, pasteurization had on the cream line. From the results of their investigations they report as follows: "The reduction in cream line of vat pasteurized milk cooled in the vat was 2.9 per cent and when cooled over the cooler 1.5 per cent. Both reductions are so low that it would scarcely be noticed on bottled milk. In the case of in-the-bottle pasteurization there was no apparent reduction in the cream line." Hammer (2) states that "in general, efficient pasteurization decreases the cream layer of milk. This decrease need not be a serious one if the pasteurization is properly carried out and the milk is properly cared for after pasteurization."

It is doubtless true that the cream layer is somewhat reduced by pasteurization; but if attention is given to certain requisites, the reduc-

tion will not be noticeable. Among the points that should be attended to, for best results as to cream line, are the following:

1. The milk should not be heated above 143° F.
2. The heating medium should not be over 8 or 10° above the temperature to which it is desired to heat the milk.
3. The milk should be heated, and also cooled, as rapidly as possible. This can be accomplished by having large heating and cooling areas and by sending the heating and cooling media through the apparatus as rapidly as possible.
4. The milk should be agitated as little as possible, especially during the holding and cooling processes.

CHEMICAL CHANGES PRODUCED BY PASTEURIZATION

As to chemical changes induced in milk by pasteurization, Rupp (3), after extensive experiments, came to the following conclusions:

"1. Milk pasteurized by the holder process at 145° F. for thirty minutes does not undergo any appreciable change.

"2. The soluble phosphates of lime and magnesia in the serum of both raw and pasteurized milk are practically the same.

"3. The albumen does not coagulate at 145° F., but 5.75 per cent of it is rendered insoluble at 150° F. As the temperature increases, the amount of coagulated albumen increases, amounting to 12.75 per cent at 155° F. and to 30.78 per cent at 160° F.

"4. The time required for coagulating the casein by rennin is slightly less in milk pasteurized at temperatures up to 149° F. than it is in raw milk. At 158° F. there is a slight retardation, while at 167° F. the time has almost doubled.

"5. The acidity as determined by titration is slightly diminished in pasteurized milk."

BACTERIA WHICH SURVIVE PASTEURIZATION

Approximately 99 per cent of the bacteria in milk are usually destroyed by proper pasteurization; and the higher the original count of the milk the greater will be the percentage reduction. However, the percentage reduction may be as high as 99.5 and the pasteurized milk may still have 100,000 or more bacteria per cubic centimeter, depending on the original count of the milk. It is not advisable, therefore, to attach too much importance to the percentage reduction.

Ayers and Johnson made an extensive investigation on the bacteriology of pasteurized milk and make the following statements regarding bacteria which survive pasteurization: (4)

" Four distinct groups of bacteria, the acid-forming, the inert, the alkali-forming, and the peptonizing, survive pasteurization, as differentiated by their reactions in litmus milk after fourteen days' incubation at 30° C. (86° F.).

" The percentage of the acid group is increased by pasteurization while the other groups are decreased in their percentage of the total bacteria. The average percentage of the lactic acid bacteria in raw milk which survive pasteurization for thirty minutes at 62.8° C. (145° F.) ranges from 1.27 per cent to 4.55 per cent in the various grades of milk.

" When different grades of milk are pasteurized at 62.8° C. (145° F.) in the laboratory and held at room temperature, the bacterial flora may undergo three distinct changes. First, when a fair quality of milk is pasteurized the acid group may develop at once and overgrow all the other groups, forming acid and producing a normal curd. Second, when a poor quality of milk is pasteurized the peptonizing group may grow rapidly at first along with the acid group, which later overgrows them. In this case the milk will first become curdled with a rennet curd due to the peptonizing bacteria, then later will become sour from the development of the lactic-acid group of organisms. Third, when a good grade of milk is pasteurized the peptonizing bacteria may overgrow the acid group of organisms so that the milk becomes peptonized without the development of any acid. These same grades of milk, treated in the same manner but held in an ice chest at 10° C. (50° F.), show entirely different changes in their bacterial contents. The growth of the peptonizing group is restrained so that they are of little importance. The percentage of the acid group remains about the same through a long period. Occasionally the percentage of the alkali group may increase after five days, but eventually the acid group forms the major group. These results were obtained from laboratory experiments and only indicate possible changes in the bacterial flora of pasteurized milk when held at different temperatures. They show the delicate balance between the bacterial groups, but cannot be applied to indicate the bacterial changes in milk pasteurized and handled under commercial conditions."

Ability of Colon Bacilli to Survive Pasteurization.—Ayers and Johnson (5) found that certain strains of *Bacillus coli* survive a temperature of 145° F. for thirty minutes and that they " develop rapidly when the pasteurized milk is held under temperature conditions which might be met during storage and delivery." The following table shows the results of the treatment of 174 cultures of *Bacillus coli*, giving the number and percentage of cultures which withstood different degrees of heat:

TABLE 90

EFFECT OF HEAT ON COLON BACILLI (5)

Cultures Surviving.	Exposed for 30 Minutes at—						
	125° F.	130° F.	135° F.	140° F.	145° F.	150° F.	155° F.
Number.....	174	173	158	95	12	1	0
Per cent.....	100.00	99.43	90.80	54.59	6.89	0.57	0

"It is seen from the table that 95, or 54.59 per cent, of all the cultures survived at 140° F. When heated to 145° F., 12, or 6.89 per cent, survived. Thus 6.89 per cent of the cultures survived the temperature generally used in commercial pasteurization."

Ability of Streptococci to Survive Pasteurization.—Ayers and Johnson (6) made a study of the ability of streptococci to survive pasteurization. The cultures used were obtained from four different sources and the results are given in Table 91

"From these results it is evident that the streptococci from the udder are, as a rule, less resistent to heat than those from the other sources. Those from the mouth and from the feces have about the same resistance, while streptococci from milk and cream were very much more resistant than those from other sources."

TABLE 91

EFFECT OF HEAT ON STREPTOCOCCUS CULTURES CLASSIFIED ACCORDING TO SOURCE (6)

Source.		Cultures Surviving After Heating for 30 Minutes at									
		120° F.	125° F.	130° F.	135° F.	140° F.	145° F.	150° F.	155° F.	160° F.	165° F.
Feces,	Number.....	45	45	45	44	31	9	2	0	0	0
	Per cent.....	100	100	100	97.77	68.88	20	4.44	0	0	0
Udder,	Number....	40	40	40	24	18	7	4	2	1	0
	Per cent....	100	100	100	60	45	17.55	10	5	2.50	0
Mouth,	Number....	36	36	35	31	22	13	7	2	0	0
	Per cent....	100	100	97.22	88.88	61.11	36.11	19.44	5.55	0	0
Milk and Cream,	Number..	18	18	18	18	18	17	13	9	2	0
	Per cent..	100	100	100	100	100	97.44	72.22	50	11.11	0

In the summary of the results of their experiments, the investigators state:

"Two classes of streptococci seem to survive pasteurization: (*a*) Streptococci which have a low majority thermal death point but among which a few cells are able to survive the pasteurizing temperature. This ability of a few bacteria to withstand the pasteurizing temperature may be due to certain resistant characteristics peculiar to a few cells or may be due to some protective influence in the milk. (*b*) Streptococci which have a high majority death point. When such is the case, the bacteria survive because the majority thermal death point is above the temperature used in pasteurization. This ability to resist destruction by heating is a permanent characteristic of certain strains of streptococci."

The term "majority thermal death point" means the temperature at which the majority of the bacteria are destroyed.

SPORE-BEARING BACTERIA SURVIVE PASTEURIZATION

It has been shown by Ford and Pryor (7) that milk always contains heat-resistant spores of bacteria which, by their development, can give rise to disagreeable and unwholesome changes in milk. These changes, however, do not take place when the milk, after being heated at pasteurizing temperature, is kept at a low temperature—say 40° F. Spores of these bacteria survive for a long time in milk kept on ice, but it has not been proved that they are injurious to health.

Suitability of Pasteurized Milk for Infant Feeding.—During an eighteen month period eight baby stations were maintained by Mr. Geo. M. Oyster, Jr., in different sections of Washington, D. C., and, in cooperation with about twenty physicians, observations were made to determine the effect of pasteurized milk for infant feeding. Graduate nurses were employed by Mr. Oyster to record facts regarding home and family conditions, to weigh the babies and observe their progress, and to dispense the prescribed milk at the stations. Raw milk was prescribed exclusively for one group of babies, and pasteurized milk was prescribed exclusively for another group. For a third group, both pasteurized and raw milk were prescribed at different times. (8)

"In the raw milk group, which included 351 babies for whom raw milk exclusively was prescribed, we find the average net gain per day per baby to be .4030 ounce.

"In the pasteurized milk group, which included 557 babies for whom pasteurized milk exclusively was prescribed, we find the average net gain per day, per baby, to be .4077 ounce—the average difference in favor of pasteurized milk amounting to .0047 of an ounce per day, per baby.

"The average net gain per day, per baby, for 110 babies fed, on both raw and pasteurized milk at different periods was .4312 ounce during the period when raw milk was prescribed and .4607 ounce when pasteurized milk was fed."

These results seem to show that no possible injury to the nutritive properties of milk can take place as a result of proper pasteurization.

Nathan Strauss, whose name stands preeminent as the result of his wonderful philanthropic work through his milk stations for children, had the milk pasteurized and saved the lives of innumerable babies.

As vitamin C is injured or destroyed during pasteurization, an infant living on milk alone must receive an anti-scorbutic such as orange or tomato juice. This, however, is good practice even with raw milk.

ADVANTAGES OF PASTEURIZATION

Proper pasteurization of milk has the following advantages:

1. It makes the milk safe by destroying any pathogenic bacteria that may be present.
2. It prolongs the life of the milk by reducing the number of lactic acid organisms.
3. It reduces the total bacterial count of the milk by approximately 99 per cent.

The most important advantage of the process is that it constitutes an additional safeguard to milk, even if it has been produced and handled under the most rigid system of inspection.

TABLE 92

COMPARISON OF EXTENT OF PASTEURIZATION OF MILK IN THE SAME CITIES FOR THE YEARS 1924 AND 1930

Population of Cities.	Number of Cities.		Number of Cities with No Pasteurized Milk.		Average Percentage of Milk Pasteurized.		Percentage of Cities with 90 to 100 Per Cent Pasteurized.		Percentage of Cities with 50 to 100 Per Cent Pasteurized.		Percentage of Cities with 10 to 50 Per Cent Pasteurized.		Percentage of Cities with 0 to 10 Per Cent Pasteurized.	
	1924	1930	1924	1930	1924	1930	1924	1930	1924	1930	1924	1930	1924	1930
500,000 and over	6	6	0	0	97.8	98.7	100.0	100.0	100.0	100.0	0	0	0	0
100,000 to 500,000	37	37	0	0	75.9	84.7	43.2	56.8	89.2	91.9	10.8	8.1	0	0
75,000 to 100,000	10	10	0	0	78.0	84.5	50.0	50.0	80.0	90.0	20.0	10.0	0	0
50,000 to 75,000	14	14	0	0	64.5	76.5	21.4	42.9	85.7	85.7	14.3	14.3	0	0
25,000 to 50,000	24	24	0	0	68.1	78.7	29.2	37.5	79.2	87.5	20.8	12.5	0	0
10,000 to 25,000	34	34	8	1	37.5	61.6	11.8	32.3	41.2	64.7	29.4	32.3	29.4	3.0

EXTENT TO WHICH PASTEURIZATION IS PRACTICED

The tendency in this country has been towards the pasteurization of all milk with the exception of certified milk and milk produced under special supervision. Table 92 shows the results of a survey made by the Bureau of Dairy Industry, U. S. Dept. Agri., of the extent of pasteurization in cities of this country in 1924 and 1930. (9)

REQUIREMENTS FOR PASTEURIZATION

Laws, ordinances, and regulations governing the time and temperature are becoming more uniform. Table 93 shows the requirements of 321 cities in 1928.

TABLE 93

MUNICIPAL TEMPERATURE AND TIME REQUIREMENTS OF MILK PASTEURIZATION

Temperature Requirements. °F.	Number of Cities.	Average Time. Minutes.	Maximum Time. Minutes.	Minimum Time. Minutes.	Time Requirements. Minutes.	Number of Cities.	Average Temperature. °F.	Maximum Temperature. °F.	Minimum Temperature. °F.
140	51	23.4	30	20	Fl*	3	173.7	176	170
142	149	30	30	30	0.5	3	165	165	165
143	9	30	30	30	1	1	165	165	165
144	5	30	30	30	3	1	158	158	158
145	88	23.8	30	20	5	3	156.7	160	155
148	1	15	15	15	10	2	156	160	152
150	3	18.3	20	15	15	3	151	155	148
152	1	10	10	10	20	14	144.4	157	140
155	3	10	15	5	25	6	143.7	145	140
157	1	20	20	20	30	285	142.5	145	140
158	1	3	3	3					
160	2	7.5	10	5					
165	4	0.6	1	0.5					
170	1	Fl*	Fl*	Fl*					
175	1	Fl*	Fl*	Fl*					
176	1	Fl*	Fl*	Fl*					

* Fl = Flash.

This table shows that 149 cities of the 321 had a temperature requirement of 142° F., and that 285 cities had a holding time of thirty minutes.

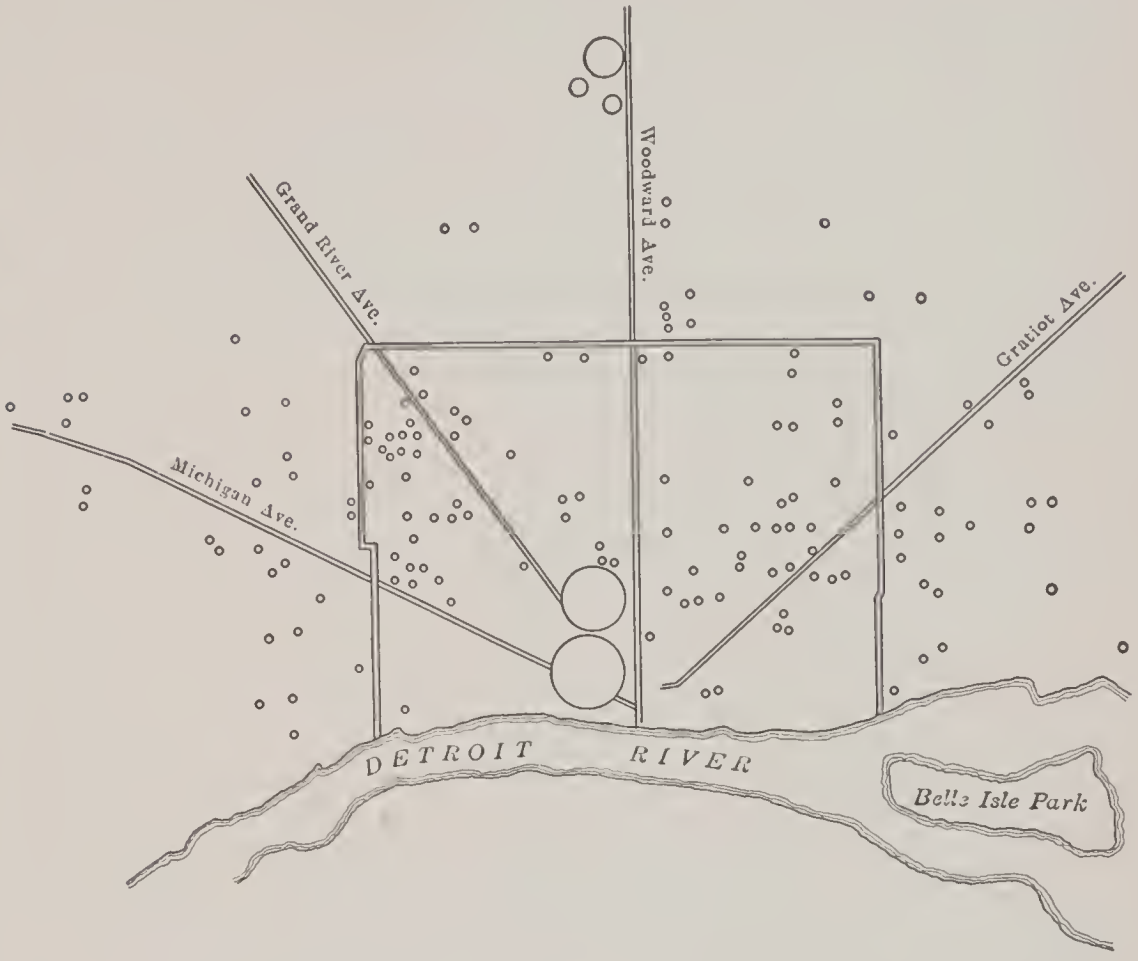


FIG. 111.—Location of city milk plants in Detroit before compulsory pasteurization. (10)

EFFECT OF ORDINANCE REQUIRING PASTEURIZATION ON THE NUMBER OF MILK PLANTS IN CITIES

The requirement by the city officials that all milk be pasteurized usually causes many of the small dealers to combine and form a larger plant, or to go out of the milk business altogether. Prior to the enforcement of the pasteurization ordinance in Detroit, Michigan, there were 158 milk dealers in the city. On August 1, 1915, three months after the pasteurization ordinance became effective, the number of plants had been reduced to 68. (10).

COST OF PASTEURIZING MILK AND CREAM

Pasteurization of milk and cream adds only slightly to the cost and, on account of the improved keeping quality of the product, it is undoubtedly advisable from a purely commercial standpoint. Bowen (11) made a study of the cost of pasteurization of milk in 1913–14 at commercial plants in actual operation. In 1922 he revised his figures,

basing them on current costs of materials and labor. The following is his conclusion:

The average cost of pasteurizing 1 gallon of milk is shown to be $0.0049.

The following are the items that were considered in the costs:

1. Depreciation and repairs of pasteurizers vats, coolers, engine, boiler, shafting, etc.
2. Interest on capital invested in above.
3. Labor for pasteurizing.

FIG. 112.—System of milk distribution in Detroit after compulsory pasteurization. (10).

4. Cost of coal at $8.16 per ton.
5. Cost of cooling water at 75 cents per 1000 cubic feet.
6. Cost of refrigeration at $2.00 per ton.

REFERENCES

(1) Judkins, H. F. and Downs, Paul A., Studies in Processing Milk. Storrs Agri. Exp. Sta. Bul. 99, 1918.

(2) Hammer, B. W., Studies of the Creaming Ability of Milk. Iowa Agri. Exp. Sta. Research Bul. 31, 1916.

(3) Rupp, Philip, Chemical Changes Produced in Cow's Milk by Pasteurization. U. S. Dept. Agri., B. A. I. Bul. 166, 15 pp. 1913.

(4) Ayers, S. Henry, and Johnson, W. T., Jr. A Study of the Bacteria which Survive Pasteurization. U. S. Dept. Agri., B. A. I. Bul. 161, 66 pp., 30 figs. 1913.

(5) Ayers, S. Henry, and Johnson, W. T., Jr. Ability of Colon Bacilli to Survive Pasteurization. Jour. Agri. Res., Vol. 3, No. 5, pp. 401–410. Feb. 15, 1915.

(6) Ayers, S. Henry, and Johnson, W. T., Jr. Ability of Streptococci to Survive Pasteurization, Jour. Agri. Res., Vol. 2, No. 4, pp. 321–330. July 15, 1914.

(7) Ford and Pryor, Observations upon the Bacteria of Milk Heated to Various Temperatures. Bul. Johns Hopkins Hospital, Vol. 25, No. 283, Sept., 1914.

(8) Weld, Ivan C., Observations Regarding the Relative Nutritive Value of Pasteurized and Raw Milk, 1914.

(9) Milk Plant Letter No. 95, U. S. Dept. Agri., Dairy Division.

(10) Clement, C. E. and Warber, G. P., The Market Milk Business of Detroit, Mich., in 1915. United States Dept. Agri. Bul. 639, 1918.

(11) Bowen, John T., The Cost of Pasteurizing Milk and Cream. U. S. Dept. Agri. Bul. 85, 12 pp. 1914.

Ayers, S. H., The Present Status of Pasteurization of Milk. U. S. Dept. Agri. Bul. 342.

Ayers, S. Henry, and Johnson, W. T., Jr. The Bacteriology of Commercially Pasteurized and Raw Market Milk. U. S. Dept. Agri. B. A. I. Bul. 126, 98 pp. 1910.

Ayers, S. Henry, The Pasteurization of Milk. U. S. Dept. Agri., B. A. I. Circular 184, 44 pp., 32 figs., 1912.

Ayers, S. Henry, and Johnson, W. T., Jr., Pasteurization in Bottles and the Process of Bottling Hot Pasteurized Milk. Journal of Infectious Disease, Vol. 14, No. 2, pp. 217–241. Chicago, March, 1914. Also U. S. Dept. Agri. Bul. 240.

Parker, H. N., City Milk Supply, 1917.

Rosenau, M. J., "The Milk Question," 1912.

Weld, Ivan C., and Oyster, George M., Jr., Baby Milk Philanthropy, Report for the first 18 months, beginning Apr. 24, 1911, and ending Oct. 24, 1912. 20 pp.

CHAPTER XX

PASTEURIZATION OF MILK (*Continued*)

PASTEURIZING MACHINERY

Pasteurizing equipment consists of heaters, holders and coolers, all of which have been developed in great variety. Coolers were considered on pages 284 to 288 on "Milk Plant Equipment." In the flash system of pasteurization (heating to a high temperature for a short period of time) only a heater and cooler are required. With the holding system the same apparatus may serve the purpose of both heater and holder, though with most systems separate units are required for each.

Heaters.—The kinds of heaters most generally used are batch heaters and continuous-flow heaters. Table 94 shows the number of plants of

TABLE 94

Number of Plants of Various Sizes Using Specified Systems of Heating Milk (4)

Number of Gallons of Milk Handled Daily.	Number of Plants.	Plants Using Batch Heaters			Plants Using Continuous-Flow Heaters					Plants Using Vat in Combination with Preheater.
		Spray Vat.	Vat.	Tank.	Danish or Kettle.	Barrel.	Internal Tubular.	Open Tube.	Film or Drum.	
500 or less	33	5	19	*5	0	3	1	0	0	0
501 to 1,000	31	3	24	3	1	3	3	0	0	0
1,001 to 2,000	44	2	15	3	2	9	12	0	0	1
2,001 to 3,000	36	1	12	4	0	6	11	0	1	1
3,001 to 5,000	44	1	6	0	3	18	15	0	1	0
5,001 to 10,000	57	2	11	0	4	19	19	0	0	2
10,001 to 20,000	29	0	3	1	1	10	12	1	1†	0
Over 20,000	22	0	0	0	5	12	4	0	1†	0
Total	299	14	87	16	16	89	77	1	4	4

* 1 starter can.

† Electropure system.

various sizes using the specified systems of heating milk. It will be noted that batch heaters are more common at the smaller plants and

that the continuous-flow heaters are more common at the larger plants. The latter statement is especially true of the barrel and internal-tubular types.

Batch Heaters.—Batch heaters are of the following types: Rectangular-shaped vat (Fig. 113), in which a coil containing the heating

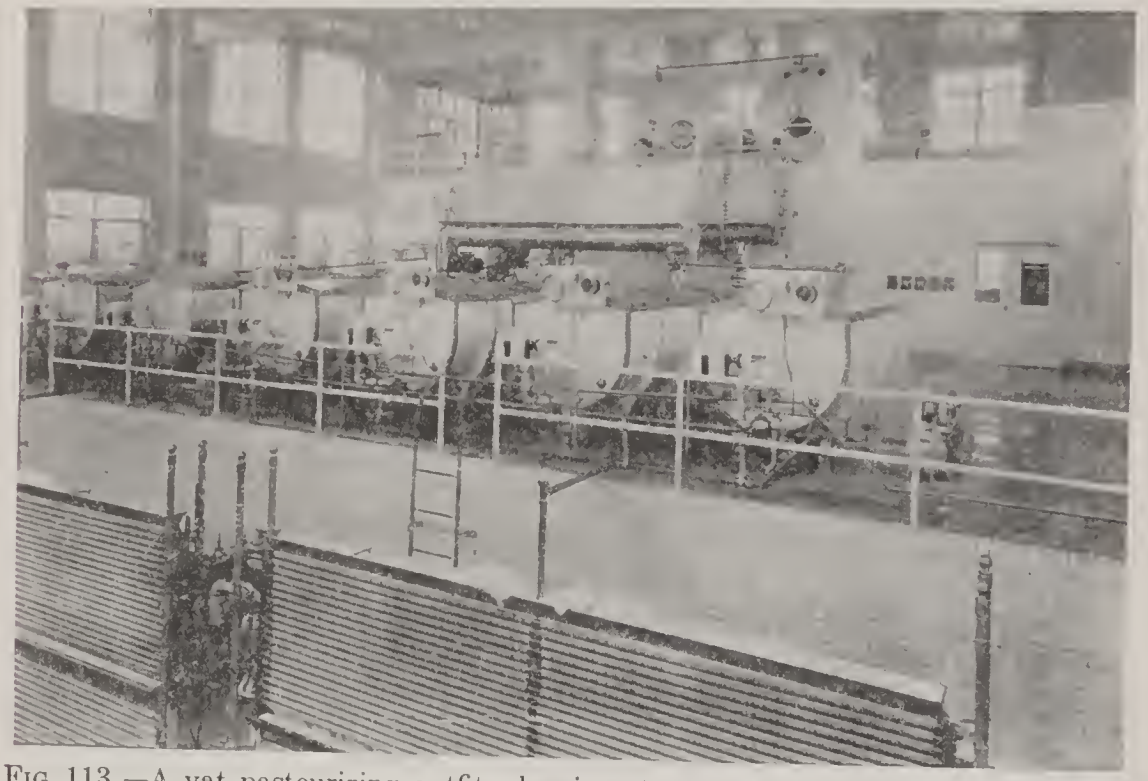


FIG. 113.—A vat pasteurizing outfit, showing storage tanks, preheater, pasteurizing vats, and tubular coolers.

medium is revolved, thus heating the milk and keeping it agitated so that the cream does not rise; vat similar to the above, except that the coil is hung vertically instead of horizontally and the vat is more nearly square than rectangular in shape; special-metal or glass-lined tank in which the milk is heated by the introduction of the heating medium in a jacket surrounding the tank, the milk in the tank being gently agitated by a revolving paddle; spray vat, similar to rectangular-shaped vat, except that it is narrower and no coil is required, as the milk is heated by forcing hot water in sprays around the outer surface of the tank. The tank containing the milk is inclosed by another tank, thus forming a jacket. The hot water, after being sprayed against the outer surface of the inner tank, flows to the bottom of the outside tank, whence it is pumped up again through pipes, being heated meanwhile to the desired temperature. Blades or paddles attached to a mechanism on the top frame of the vat keep the milk agitated during the process.

Batch heaters are simple in construction and easily operated. For

small plants vats or tanks are economical on account of their many uses. Besides serving as heaters they are used as holders and may also be used in place of receiving and storage tanks. The milk when received may be dumped into the vats and held at the desired temperature until ready for pasteurization. At small wholesale plants the milk, after being heated and held, is sometimes cooled in the vats and stored in them at a low temperature until it is drawn into cans ready to be sent out on the delivery routes. If the batch heaters and holders are properly operated all the milk will be held at the pasteurization temperature for the required length of time, although some of it will be held slightly longer than thirty minutes. During the holding

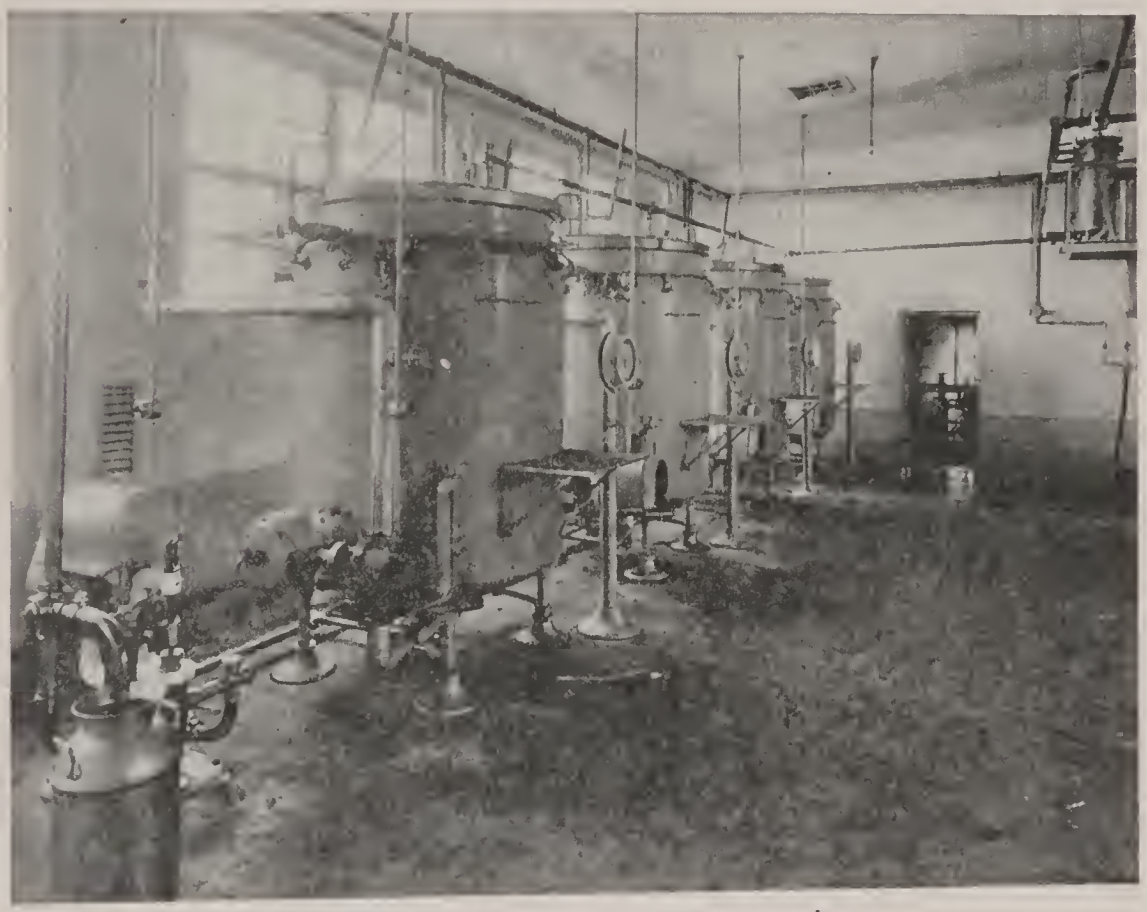


FIG. 114.—A battery of tank pasteurizers.

process the milk comes in contact with no additional surfaces between the heating and cooling processes, so that there is no extra apparatus to keep clean or to recontaminate the milk. Where batch heaters are used the capacity of the plant may be readily increased by adding more units.

Although it is possible to cool the milk completely in the vats after pasteurizing by forcing cold water and brine through the coils, this is not a desirable practice when milk is to be put into bottles. It is then

desirable to use a separate cooler, as cooling in the vat below a temperature of 100° F. (2) tends to injure the cream line.

A continuous system of pasteurization may be obtained by installing a battery of three or more vats or tanks. (Fig. 113.) While the third vat is being filled and heated the milk in the second is being held and that in the first is being drawn off over the cooler, which should be of ample capacity to cool the milk as fast as it is drawn from the vats. If the milk is cooled to about 110° or 115° F. in the vats before it is allowed to go to the cooler all the milk will be held at the pasteurizing

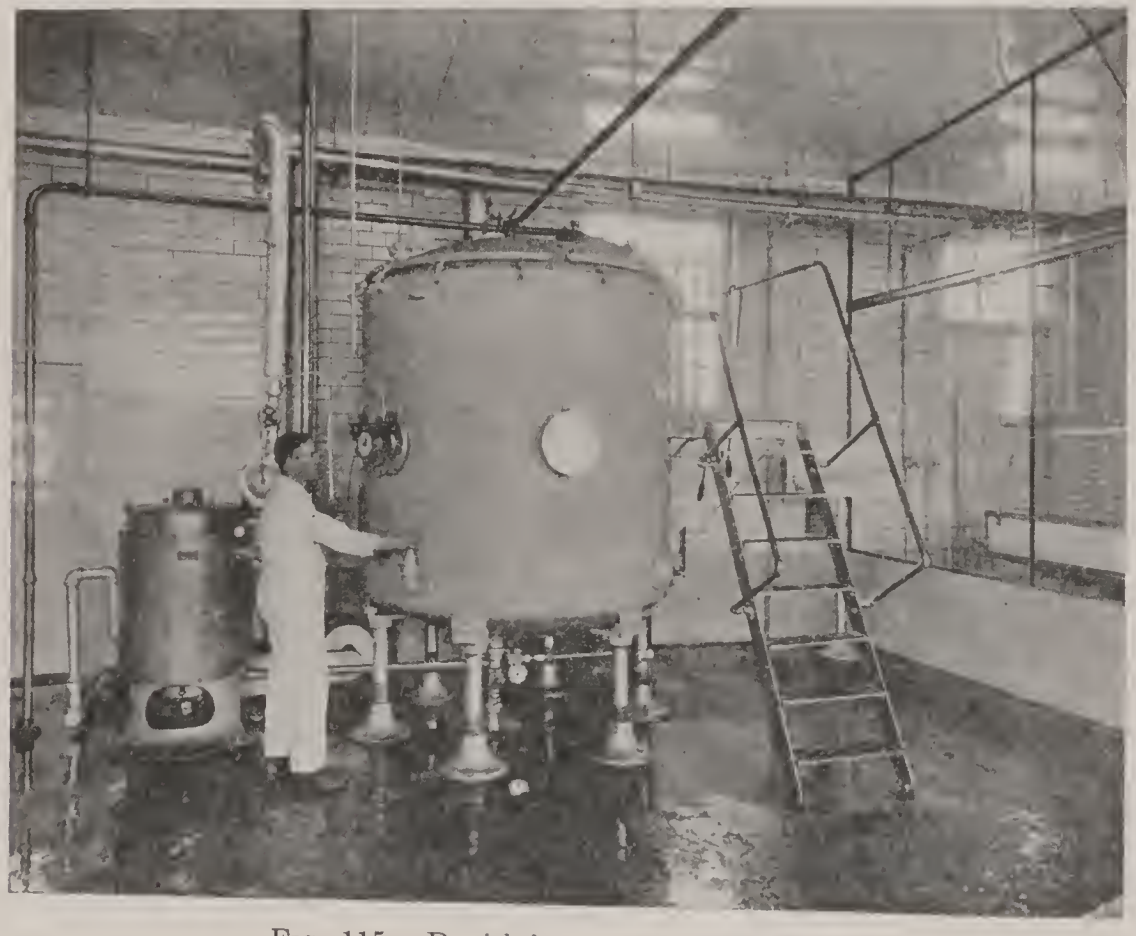


FIG. 115.—Danish heater with tank holder.

temperature for a uniform length of time and the capacity of the outfit will be increased. Another advantage of precooling is that the recording thermometer will show the exact time the milk has been held at 145° F. The vats should be kept closed to avoid contamination from the air and also evaporation of the milk. It is important that the coils revolve at the proper speed. If they are allowed to revolve too fast injury to the cream line may result.

At plants where the flow of milk to and from the vats is not automatically controlled the attendant must spend a considerable portion

of his time operating the valves. Since it is possible for him to slight the holding time without its being detected by the records, a dependable man for his work is essential.

Continuous-flow Heaters.—In general continuous-flow heaters are of greater capacity for the amount of floor space required than are batch heaters. Continuous-flow heaters are of the following types: Danish or kettle heater (Fig. 115), barrel heater, drum or film heater, and internal-tubular heater. The Danish or kettle heater consists of a kettle-like chamber surrounded by a jacket. Live steam enters the jacket through small jets. This steam condenses and the jacket is filled with hot water, which heats the milk. The temperature of the water is maintained by the introduction of steam through the jets.

The milk enters the pasteurizer at a point near the bottom and is thrown against the sides of the hot-water jacket by a revolving paddle and forced out through a pipe at the top of the machine. Milk can be elevated several feet with this machine.

The barrel heater (Fig. 116) consists of a series of pipes surrounded by a hot-water jacket. The milk is heated by the introduction of live steam into the jacket. The milk enters at the bottom and passes back and forth from one end to the other through the various pipes and finally comes out at the top through a pipe. The milk pump is placed in front of the machine and the milk is pumped through the series of pipes or tubes. A thermometer is placed in the outlet pipe of both the Danish and barrel types of heaters.

Very little floor space is required for the Danish and barrel heaters. They may be used with almost any type of holder and are used also where the flash system of pasteurization is practiced. This system of pasteurization is not to be recommended, but the heating units are satisfactory if used with a holding device. These heaters require only a comparatively small investment. Cleaning is not difficult, as the area with which the milk comes in contact is not large. Accurate control of the temperature, however, is rather difficult. The heating surface is so small that the heating medium must be of a considerably higher temperature than that to which the milk is to be heated and steam is introduced directly into the heating chamber. As the temperature of the medium is sometimes allowed to become as high as from 190° to 200° F., portions of the milk may be overheated unless considerable care is exercised. The flow of the milk to the machine, as well as its temperature, will fluctuate somewhat, and unless an accurate automatic temperature control is attached there is almost certain to be an unevenness of temperature in the milk as it comes from the heater, even though a man spends his entire time operating the machine.

Good results are obtained by using a preheater or a regenerator in conjunction with these heaters. In this way the capacity is increased, and the tax on the machine lessened; extremely high temperatures need not be used. At some plants using this system of pasteurization the milk is heated to from 110° to 120° F. before it enters the pasteurizer proper; thus the milk has to be heated only 25° to 35° more in the machine. Much more satisfactory and uniform results are obtained in this way. Temperatures obtained with preheating systems are shown in Table 96, page 351.

A combination of the barrel or Danish heater and a series of vats or tanks will produce good results. The milk can be heated to 120° to 135° F. before it goes to the vats or tanks, and thus the dangers of overheating can be eliminated. The remainder of the heating will be accomplished in the vats or tanks, and the milk will be held in them until it is to be cooled.

In the drum or film heater the milk flows either in a thin film through two or more upright heating surfaces or over a drum inside of which is the heating medium.

With the internal tubular heater (Fig. 97) the milk passes through a tube inclosed within another tube. In some of these heaters the outer tube is insulated to prevent loss of heat by radiation. The temperature of the water is maintained by the introduction of steam before it enters the tubes. With the usual types of this machine the hot water enters at one end and is discharged at the other end, traveling in the direction opposite to that in which the milk travels. Thus the temperature of the water when it is discharged from the machine will have been reduced nearly to that of the milk. Furthermore, the milk is heated without any extreme fluctuations of temperature. As the water can be forced through the tubes rather rapidly and the area of the heating surface is comparatively large, the temperature of the water need not be much higher at any time than the temperature to which the milk is to be heated.

In one of the modern internal-tubular heaters the machine is divided into sections and the hot water enters and discharges from each section as a unit. With this system it is necessary to heat the water in each section to a temperature only slightly higher than that to which the milk is to be heated, and the water is used more efficiently than in the older types of tubular heaters, as it does not travel over so great an area before it is discharged.

The following are some of the advantages of the internal-tubular heater:

Simplicity.

Comparative inexpensiveness of some types.
Adaptability to increase in capacity by adding additional units.
Durability—few moving parts to get out of repair.
Easy utilization of the regenerative principle of heating, which makes for economy of heat and refrigeration.
Easy sterilization, since by closing the ends of the tubes steam can be introduced under pressure and the apparatus thoroughly treated.
Extremely high temperatures of the heating medium not necessary.

The pipes or tubes of this type are made to stand pressure, and steam may be introduced into them under pressure for treatment to kill bacteria. These machines are constructed in small units, so that they can be adapted to plants of various sizes, and the capacity of the heater may be increased at any time by the installation of additional units.

It is very important that pumps supplying milk to all continuous-flow heaters should not be run too fast and that a uniform quantity of milk should be allowed to flow to the pumps. All machines should have automatic temperature controls.

Holders.—After the milk has been heated to the pasteurizing temperature it must be held at that temperature for thirty minutes. In

TABLE 95.

NUMBER OF PLANTS OF VARIOUS SIZES USING SPECIFIED KINDS OF HOLDERS (4)

Number of Gallons of Milk Handled Daily.	Total Number of Plants.	Plants Holding Milk in—						
		Batch Holders.					Continuous-flow Holders.	
		Vat.	Tank.	Spray Vat.	Stationary Pocket.	Revolving Pocket.	Tubular.	Flow Tank (Retarder).
500 or less....	35	20	6*	5	2	0	1	1
501 to 1,000..	33	21	5	3	1	0	3	0
1,001 to 2,000	42	17	11	3	6	0	5	0
2,001 to 3,000	34	17	7	1	3	0	6	0
3,001 to 5,000	43	9	6	1	19	0	8	0
5,001 to 10,000	59	19	7	2	13	2	15	1
10,001 to 20,000	27	5	7	0	9	1	5	0
Over 20,000....	21	3	10	0	5	1	2	0
Total.....	294	111	59	15	58	4	45	2

* 1 starter can.

order that the holding temperature may be maintained for the required length of time, the apparatus should be insulated or jacketed. The holder is usually separate from the heater. In general there are two types of holders—batch holders and continuous-flow holders.

Table 95 shows the number of plants of various sizes using specified kinds of holders. Although the batch holders were the more common, a large number of the continuous-flow holders of the tubular type were in use. Only two flow-tank holders were in use at the plants

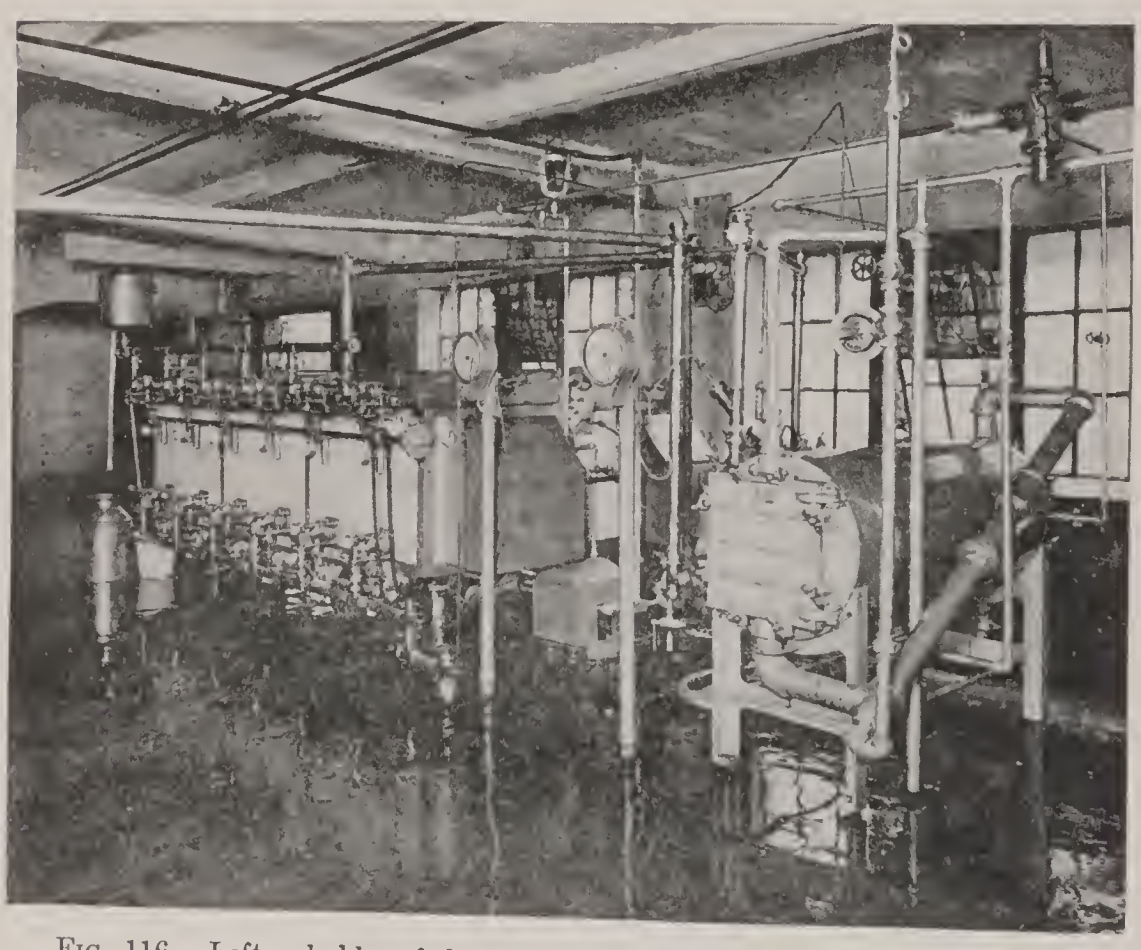


FIG. 116.—Left, a holder of the compartment type; right, a barrel heater.

surveyed. The use of this type of holder is prohibited by many departments of health because of the lack of accuracy of the holding time.

Batch Holders.—Batch holders may be divided into vat or tank holders and pocket holders. The vats or tanks may also be used as heaters, a description of which is given on pages 341 to 344. The walls are insulated or jacketed so that the pasteurizing temperature is maintained during the holding process. In some cases the valves controlling the flow of milk to and from these vats or tanks are operated by hand, and in other cases the entire operation is automatic.

At small plants where only one or two tanks or vats are used the method of operating by hand is rather common.

Pocket holders are either stationary or revolving. One type of stationary pocket holder consists of a series of tanks into which the heated milk flows, and from which it is released after the holding period, the process of letting the milk in and out being automatic. Another type has a series of compartments with valves at the entrance and discharge end of each (Fig. 116). These valves are automatically controlled by a revolving mechanism which is operated by a motor.

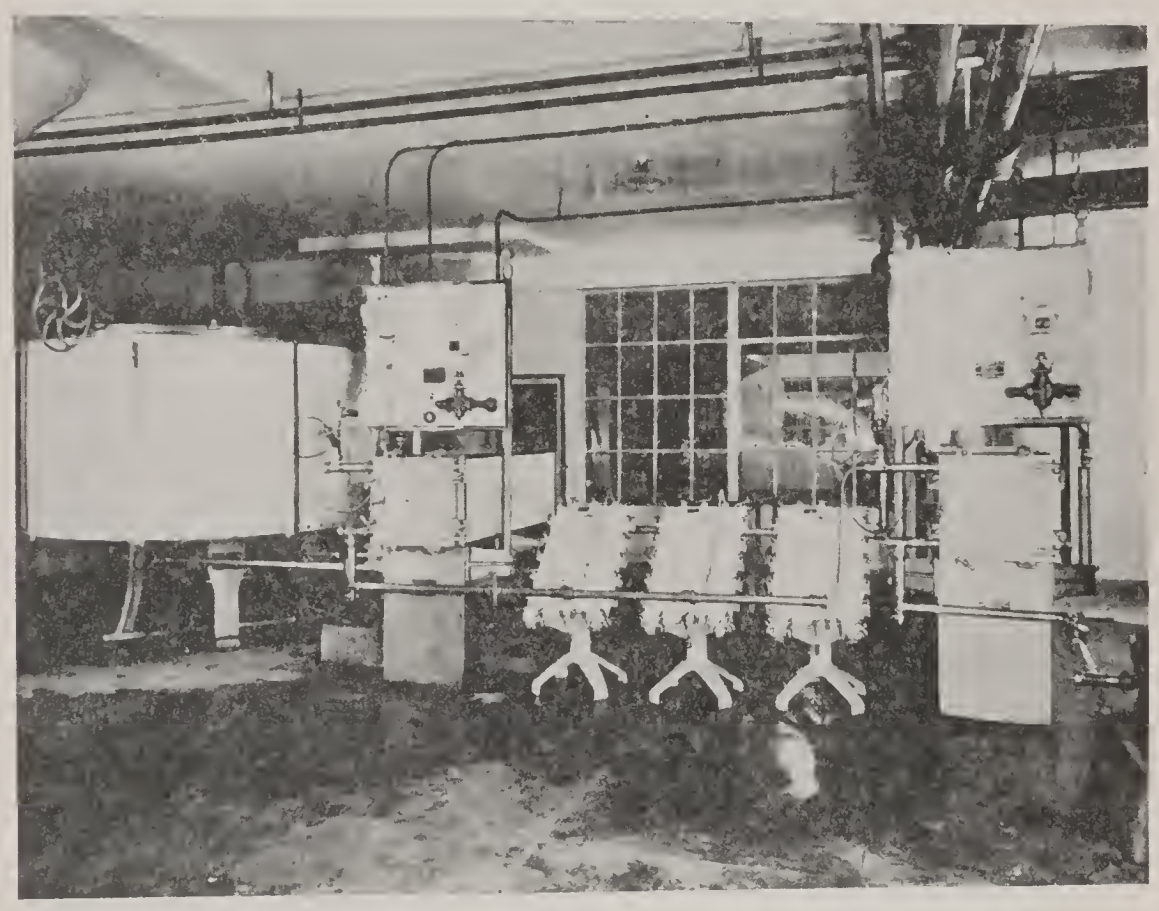


FIG. 117.—Revolving pocket holder with heater and filters at right.

These holders should be checked from time to time to see that the operation of the valves is perfectly controlled, that none of the valves leak, and that the valve at the discharge end of the compartment to be filled is always closed tight before the milk begins to flow in so that none of the milk will pass through without being held.

The revolving pocket holder shown in Fig. 117 is divided into eight compartments. The milk flows from the heater to one of these compartments. The device revolves slowly, and when the particular compartment reaches a certain point the milk is automatically released through a passage and it then goes to the cooler. As the tank revolves

this compartment is again filled. The apparatus is so controlled automatically that thirty minutes elapses from the time any compartment is filled before the milk is released to the cooler.

Neither the stationary nor the revolving type of compartment holder, if operated properly, holds the milk much longer than one-half hour, as a compartment is emptied in a comparatively short time.

Continuous-Flow Holders.—In the continuous-flow holders the flow of milk is retarded by some obstruction, such as baffle plates or turns in the apparatus. One type of holder consists of a series of tanks. The milk flows from one tank as soon as it is full to the next

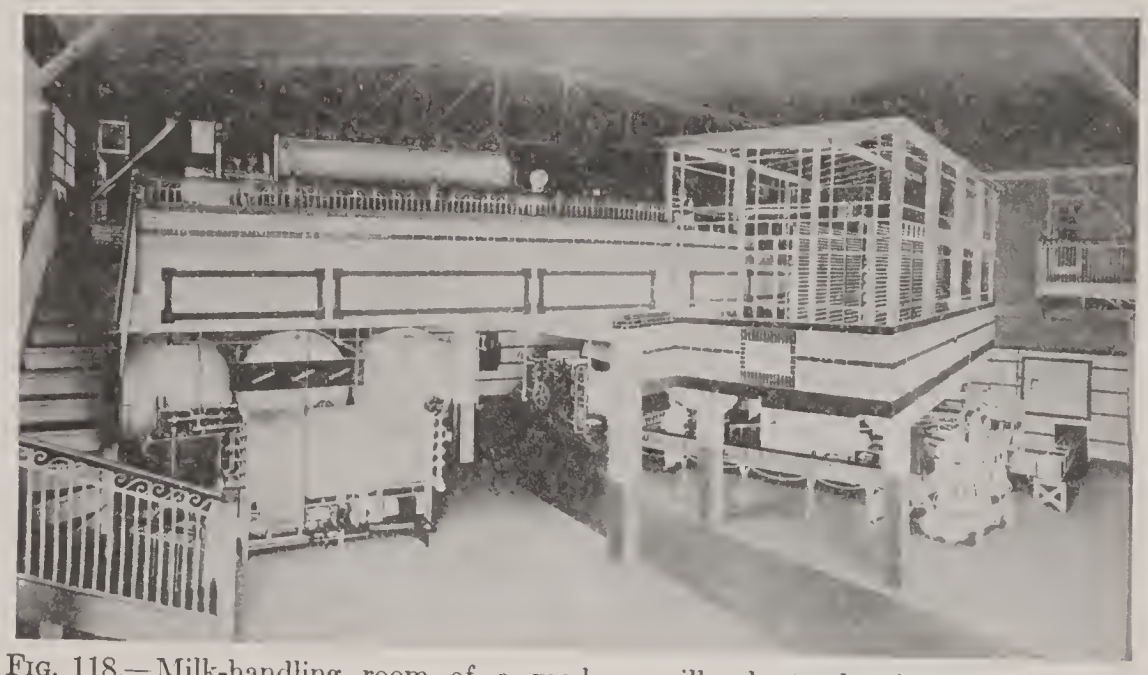


FIG. 118.—Milk-handling room of a modern milk plant, showing storage tanks and heater at left and revolving continuous-flow holder on the mezzanine floor.

tank. It is supposed to take thirty minutes for the milk to flow from the entrance of the first tank to the discharge end of the last tank, but tests have shown that the holding time is not always uniform.

Another type of continuous holder consists of a series of long tubes through which the milk passes from the heater to the cooler. Tests have indicated that this holder is accurate as long as the pump is operated at the specified speed. (Figs. 91 and 97.)

In still another type (Fig. 118) the milk enters at one end of the apparatus, which slowly revolves and gradually forces the milk to the other end, where it is discharged to the cooler. The revolution of this apparatus is automatically controlled and it cannot be made to revolve above the specified speed. This holder has only recently been developed, but very satisfactory results are reported from those in use.

Tests to Determine Accuracy of Holders.—Good results have been obtained with many continuous-flow holders. In some types, however, some of the milk may not be held so long as the rest, or all of it may be forced through the apparatus and none be held the proper length of time. Tests should be made on all continuous holders to ascertain whether the milk is being properly held, and only those holders that are accurate should be used.

Several tests are quite reliable, among them the color tests and the temperature test. With the color test the holder is filled with water and the apparatus set in operation in the usual way. A solution of a substance of a distinctive color is introduced at the entrance of the holder and the time that the color first appears at the outlet of the holder is observed by the operator. Methylene blue and uranin have been used for the operation of the color test. With the temperature test the temperature of the water as it enters the holder is suddenly raised or lowered several degrees and the time at which the temperature of the water at the outlet of the holder changes is noted. Certain kinds of bacteria which produce a distinctive color have also been used for testing the accuracy of the holding time of continuous-flow holders.

Regenerative Principle in Pasteurization.—By applying the so-called regenerative principle of pasteurization many plants are able to cut down the amount of heat and refrigeration required. This principle may be applied when either milk or water is used as the heating or cooling medium. With one type of milk-regenerative system the cold, raw milk before going to the pasteurizer passes through the first section of the cooling tubes over which the hot milk from the holder flows. With the other type the cold, raw milk passes over the outside of the tubes and the hot pasteurized milk coming from the holder passes through the tubes. With these milk regenerative systems the incoming milk is often heated to between 110° and 120° F. before it goes to the heater proper, while the hot, pasteurized milk is precooled by the incoming milk often to 60° to 70° before it reaches the tube containing the cooling water.

With the water-regenerative system the water from the first section of the cooler, having been heated to within a few degrees of the hot milk which passes over the tubes through which the water flows, needs to have only a few heat units added to it before it goes to the preheater to heat the incoming milk. The water from the heater, having been cooled by the incoming milk, goes to the cooler, where it is used for precooling the hot milk.

Table 96 and Fig. 119 show the results of a study made at 51 plants using the milk-regenerative system and 17 plants using the water-

TABLE 96

TEMPERATURES OF MILK AT PASTEURIZING PLANTS USING MILK OR WATER REGENERATION (4)

System of Regeneration.	Total Number of Plants.	Temperature of Milk as Received. °F.		Temperature of Milk after being Pre-heated by Regeneration. °F.		Degrees of Heat Added to Milk by Regeneration. °F.		Temperature of Milk Coming from Pasteurizer. °F.	
		Aver-age.	Range.	Aver-age.	Range.	Aver-age.	Range.	Aver-age.	Range.
Milk.....	51	42.6	33–55	113.1	70–130	70.5	25–90	143.4	140–145
Water.....	17	47.7	38–60	101.5	75–120	53.8	35–81	143.2	142–145

TABLE 96

TEMPERATURES OF MILK AT PASTEURIZING PLANTS USING MILK OR WATER REGENERATION (4)—*Continued*

System of Regeneration	Total Num-ber of Plants.	Degrees of Heat Added to Milk by Steam or Hot Water (° F.)		Temperature of Milk after Being Pre-Cooled by Regeneration (° F.)		Degrees of Heat Taken from Milk by Regeneration (° F.)		Final Temper-ature of Milk (° F.)		Degrees of Heat Taken from Milk by Refrigeration (° F.)	
		Aver-age.	Range.	Aver-age.	Range.	Aver-age.	Range.	Aver-age.	Range.	Aver-age.	Range.
Milk.....	51	30.1	13–73	77.5	50–120	65.6	23–93	39.8	35–50	37.4	13–70
Water.....	17	41.8	24–68	85.5	50–120	57.8	23–105	39.1	35–45	46.4	10–108

regenerative system. Although both systems effect economies in the use of steam and refrigeration, the milk-regenerative system is slightly more efficient, since the hot milk from the holder directly heats the incoming cold milk, and vice versa. On an average, the milk was preheated 70.5° F. with the milk-regenerative system and 53.8° with the water-regenerative system, and was precooled 65.6° with the milk-regenerative system and 57.8° with the water-regenerative system. From a sanitary standpoint, however, the milk-regenerative system is somewhat less desirable because the inside of the pipes through which the incoming raw milk passes must be cleaned after each run.

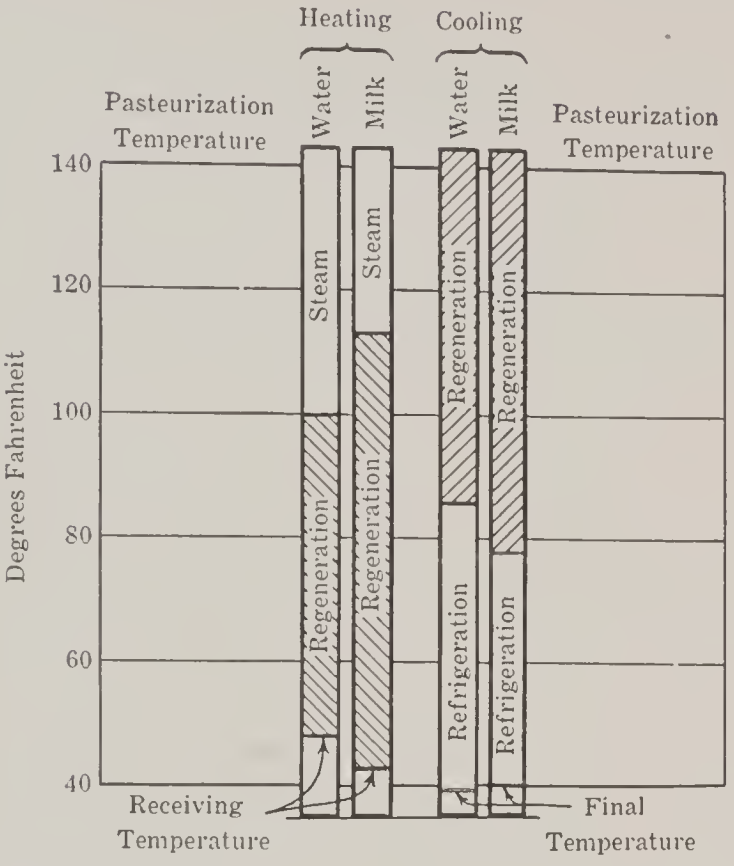


FIG. 119.—Comparison of efficiency of milk and water regenerative systems in heating and cooling milk (17 plants, water-regenerative system; 51 plants, milk-regenerative system) (4)

At many plants the milk is preheated by regeneration to from 85° to 90° F. before it goes to the clarifier or filter. At these temperatures the clarification or filtration is more efficient, and less foam is produced than if the operation is performed when the milk is cold. Preheating also helps to render the pasteurization of the milk more uniform, as the milk goes to the machine at a fairly constant temperature.

Table 77 shows that at 27 of the 56 plants using clarifiers the milk was preheated before it went to the clarifier, and Table 78 shows that at 83 of the 245 plants using filters the milk was preheated before it went to the filter. In many cases regeneration is used for the preheating process.

OTHER SYSTEMS OF PASTEURIZATION (4)

In-the-Bottle Pasteurizers.—With the in-the-bottle system of pasteurization the milk is pasteurized and cooled after it has been put into the bottles. In some pasteurizers the bottles of milk in the cases are heated, held, and cooled in the same apparatus or compartment. In others the bottles of milk, after being removed from the cases, pass slowly through the machine, being heated at the beginning and cooled at

the end of the process. It takes 30 minutes for the bottles of milk to pass from the point where they have been heated to the pasteurizing temperature to the point where cooling is begun. The milk usually is heated by passing sprays of hot water over the bottles. Either a special cap is used or the bottles are covered with a specially constructed pan. In the latter case the hot water flows through small holes in the pan and passes over the bottles in the form of a film. The milk is cooled by changing from hot water to cold. With some types of in-the-bottle pasteurizers, after the milk has been heated, held, and cooled it remains in the machines and is kept at a low temperature until time for delivery. With one type, the milk in the bottles is heated by live steam and cooled by immersing the bottles in cold water. With still another type the bottles of milk are heated by being immersed in vats containing hot water.

The chief advantages of this system of pasteurization are as follows: (*a*) It has no apparatus, pumps, and pipes to be cleaned; and (b) there is little chance of the milk being recontaminated after pasteurization, provided water-tight caps are used and the bottles do not have to be recapped, as the milk does not come in contact with any other apparatus after pasteurization. The chief disadvantages of this system are as follows: (*a*) It is rather slow for a large plant; (*b*) it requires considerable floor space; (*c*) the cost of operation is greater than with the other systems of pasteurization, since extra heat and refrigeration are required to heat and cool the bottles and caps and, with some types, the cases also; and (*d*) either a more expensive cap must be used or many of the bottles may have to be recapped, in which case the milk may be recontaminated. Because of these disadvantages, this system is not used to any great extent.

Pasteurization by Electricity.—A system of pasteurizing milk by electricity has been developed in recent years. Usually with this system the milk is cooled at once, without the usual thirty-minute holding period. Anyone contemplating its use should take into consideration the following factors: (*a*) Whether or not this method of pasteurization without holding will receive the approval of the local health authorities and (*b*) the cost of operation as compared with that in other systems. This cost will depend largely on the rate at which electricity can be obtained from the electric-power companies and will vary greatly in different localities. The equipment required for this system is very simple and can easily be cleaned. Furthermore, comparatively little floor space is required.

Miscellaneous Equipment. *Temperature Regulator.*—It is essential that the temperature of pasteurization be accurately controlled,

not only to procure efficient pasteurization but also to avoid injuring the cream line and the chemical properties of the milk. An accurate automatic device for controlling temperatures should be installed on all pasteurizing outfits.

Recording and Indicating Thermometers.—All pasteurizing outfits should also be supplied with thermometers which will record the temperature to which the milk has been heated. These instruments will also record the time required to heat the milk, and in some cases they can be so installed as to show the time the milk has been held at the pasteurizing temperature. From the records made by these instru-

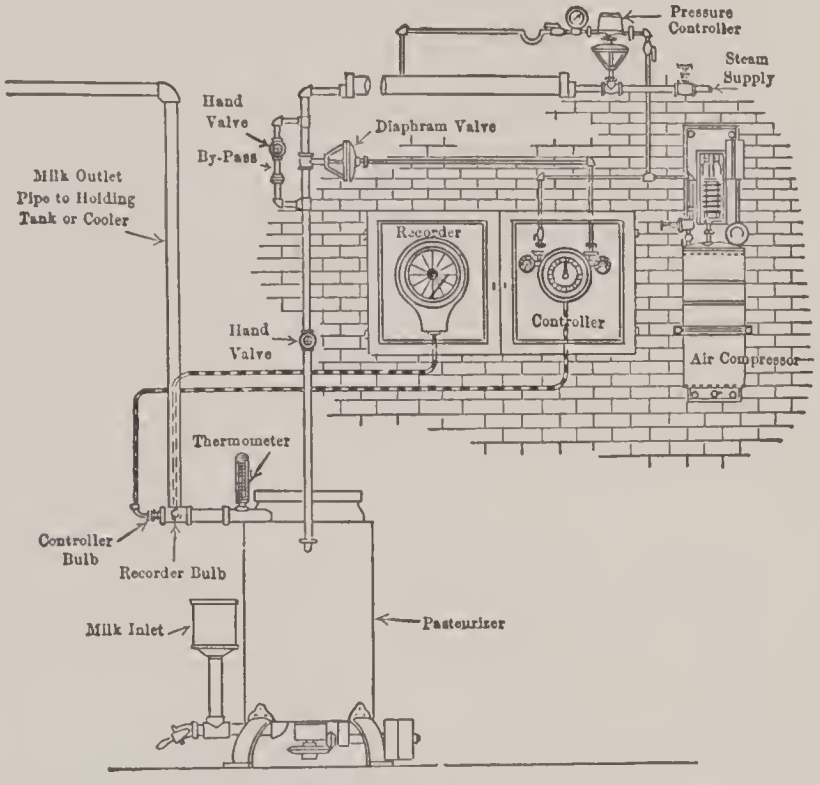


FIG. 120.—Diagram of automatic temperature control for pasteurizing plants.

ments the plant superintendent is enabled to keep a reliable check on the operator of the pasteurizer.

In addition to recording thermometers, pasteurizing outfits should also be equipped with indicating thermometers. The divisions on the scale of such thermometers should be large, so that the temperature that is registered can be readily observed by the operator.

Special Kinds of Valves.—It is important that the heater or holder have no pockets or dead ends in which the milk is not subjected to the heating process or to sufficient agitation to keep the temperature up to the required point during the holding period.

Flush-type valves should be installed on all pasteurizing apparatus

where there is any likelihood of such trouble. Leak-detector valves should be used in inlets and outlets of pasteurizing vats or other apparatus where a leak in the valve might result in some of the milk passing through the apparatus without being heated or held the required length of time. With the use of these leak-detector valves if any milk does leak it will drop on the floor.

SELECTION OF PASTEURIZING EQUIPMENT

A large number of different types and styles of pasteurizers are on the market, and the purchaser should know what requirements are to be fulfilled before attempting to select a machine. In general, the type of pasteurizer selected should be adapted to the particular plant for which it is intended. A small plant will often require a different type of machine from a large one. A plant handling milk only may require a different type from that required by one handling by-products also.

Other questions which have a bearing on the selection of a pasteurizer are: Is the daily output constant? Is the business increasing or constant? The large dealer must have a machine that will handle a large volume of milk in a short time.

Among the points to be considered in the selection of a pasteurizer are the following:

1. Simplicity of the machine.
2. Ease of cleaning.
3. Ease of treating to kill bacteria.
4. Economy of operation.
5. Avoidance of high temperatures in the heating medium, by having a large heating area.
6. Accuracy of holding.
7. Initial cost.
8. Durability.
9. Avoidance of chance of forcing the milk through at too high a speed.
10. Adaptability to increased capacity by installing additional units.
11. Minimum of agitation of the milk.
12. Minimizing human element in operation.
13. Heating all the milk uniformly.

A pasteurizer with parts not easily accessible will require extra time for cleaning, and should be avoided.

OPERATION OF A PASTEURIZING PLANT

The proper operation of the pasteurizer is one of the most important duties to be performed in a milk plant, and it is essential that a competent and reliable man be assigned to this work.

In operating a pasteurizing plant three main objects are desired, namely: (*a*) the destruction of all disease-producing bacteria and the reduction of the total number of bacteria in the milk, with the consequent improvement in the keeping quality; (*b*) the economical use of heat, power, and labor; and (*c*) a good, well-defined cream layer in the bottled milk.

In order to pasteurize milk properly, two things are necessary:

1. Heating and holding the milk at the proper temperature, with an accurate control of the temperature. (The milk should be heated to 142° to 145° F. for thirty minutes.) After being heated, and held 30 minutes, the milk must be cooled to 45° F. or below.

2. All apparatus which comes in contact with the milk must be thoroughly cleaned and steamed after each using.

The cleansing and steaming of the apparatus is absolutely essential for good results. All milk pipes, pumps, and filler valves must be thoroughly cleaned and rinsed after each run and then steamed for at least five minutes. The pasteurizer also must be thoroughly washed, rinsed, and steamed. Some plants get poor results after heating and holding the milk at proper temperature, because the pipes and other apparatus are not properly cleansed and steamed. All bottles and cans must be thoroughly cleansed and treated to kill bacteria, or the value of the pasteurization will be greatly reduced.

Some Causes of Poor Pasteurizing Results.—Some of the causes of poor results from pasteurization are:

1. Pipes and pumps not cleaned and steamed.
2. Filler and valves not cleaned and steamed.
3. Milk rushed through the apparatus too fast.
4. Milk not heated high enough or held long enough.
5. Temperature recorder not accurate.
6. Raw milk added to pasteurized milk in vat (vat pasteurizer) before the latter is all drawn out.
7. Pumps and piping not of sanitary construction.
8. Leaky or inaccurate valves which allow some of the milk to get through the apparatus without being held the proper length of time.
9. Formation of foam in the holder.
10. Bulb thermometer not accurate.

Important Points in Pasteurization.—The following are important facts to consider in pasteurization:

1. Milk to be pasteurized should not contain an excessively large number of bacteria.
2. Heaters with large heating area are desirable, and high temperature of the heating medium should not be used.

3. The holding process must be positive and accurate, and so-called continuous holders should be tested often as to accuracy of holding.

4. Automatic temperature control is essential for all pasteurizers.

5. Temperature-recording instruments should be used at all pasteurizing plants.

6. The heating and the cooling of the milk should be done quickly for best results.

7. The milk should be stored after pasteurization in a well-insulated storage room at a temperature of 45° F. Milk should be iced on the delivery wagons during warm weather.

8. Leaky valves in the apparatus should be avoided.

9. When continuous pasteurizers are used, the speed of the pump which forces the milk through the apparatus should be accurately controlled so that the milk will go through the apparatus at a uniform speed. When the milk flows through the apparatus by gravity, float valves are sometimes used to control the flow.

10. Live steam under a small pressure should be applied to the pasteurizing equipment each day.

Great care should be taken to see that valves in the pipe line do not leak. Leaky valves are a very common occurrence in many milk plants, and, besides being very insanitary, they cause much loss of milk. No pains should be spared to keep all valves and connections in the milk lines tight.

The proper pasteurization of milk is a simple operation, and there is little excuse for the poor results that are obtained at some plants. Poor results are usually not the fault of the type of pasteurizer used, but of the way in which it is operated.

Cleaning the Pasteurizer.—As soon as the milk is out, water should be run through the whole apparatus, and may be followed by a solution of washing powder. It will then be necessary to take the apparatus apart, disconnect the pipes and go over the entire equipment with brushes and solutions of washing powder. After the entire outfit has been thoroughly cleaned, it should be rinsed with hot water, followed by live steam. After the apparatus is put together and all joints connected, live steam can be put through it again.

LABOR REQUIRED FOR PASTEURIZING AND COOLING MILK AND CLEANING EQUIPMENT

Table 97 shows the relation between the size of plant and labor requirements for pasteurizing and cooling the milk and for cleaning the equipment at 112 plants. According to the table, labor for pasteurizing and cooling milk can be used more economically in large plants than in small ones. At least one man must be detailed to the pasteurizing department in plants of all sizes. Even in small plants this

TABLE 97

RELATION BETWEEN THE SIZE OF PLANT AND LABOR REQUIREMENTS FOR PASTEURIZING AND COOLING THE MILK, CLEANING THE EQUIPMENT AT 112 PLANTS (3)

Group	Milk Handled. Gallons.	Plants. Number.	Milk Pasteurized and Cooled per Man-hour. Gallons.	Labor Required per Day for Cleaning Pasteurizing Equipment. Man-hours.	Milk Pasteurized and Cooled per Man-hour (Including Cleaning Equipment). Gallons.
1	3,000 or less.....	24	439	3.7	246
2	3,001 to 5,000...	22	690	5.0	341
3	5,001 to 10,000..	38	982	9.3	434
4	10,001 to 15,000..	17	1290	17.3	476
5	Over 15,000.....	11	1588	24.4	450

man can do little more than attend to the pasteurizing equipment during the operation. Since large plants usually require not more than two men, the quantity of milk handled per man in large plants is much greater than in small plants.

At small plants the man who operates the pasteurizer often does some cleaning during the last part of the run. This fact partly accounts for the comparatively small number of man-hours for cleaning charged to these plants, as shown by Table 97. Many large plants have found it desirable and economical to employ men to spend their entire time in cleaning the pasteurizing and cooling equipment. This system, however, would not be practical for small plants. When the total amount of labor for pasteurizing the milk and cleaning the equipment is considered there is not a great difference between the quantity of milk pasteurized per man-hour at the small plants and at the large ones.

CREAM LAYER

Two important qualities of market milk are safety and richness. The richness is judged by the housewife almost wholly by the amount of cream that can be seen at the top of the bottle, and not by the actual butterfat content as determined by the Babcock test.

In the pasteurization of milk some difficulty has been experienced with variations in the depth of the cream layer. The consumers who

observe this often believe they are receiving milk below the legal requirement in butterfat. A uniform and satisfactory cream layer on pasteurized milk is considered very important by health officials, because it is difficult to induce the public to purchase any grade of milk which does not show a satisfactory cream layer. Moreover, on account of the keen competition that exists among milk dealers, the cream volume on the bottled milk is of great commercial importance.

It has been understood by many plant operators, and some investigators have shown, that pasteurization of milk decreases the cream volume to some extent. From the variation in the cream layer obtained by various dealers, it is apparent that the methods used in pasteurization as well as the effect of other operations in the handling of the milk, both before and after pasteurization, have an important bearing on this problem.

Many investigations have been carried on to determine what are the essential factors for securing the maximum cream layer on pasteurized milk.

Dahlberg and Marquardt (1) came to the following conclusions:

"The essentials of securing the maximum cream layer volumes on pasteurized milk of a given fat content are as follows:

"1 The fat globules should be retained in their normal condition by prevention of excessive churning, agitation, freezing, or oiling off.

"2. Pasteurization should be slightly less than 145° F. for a holding period of thirty minutes.

"3. Milk should be cooled by a surface tubular cooler to 40° F. or below and bottled immediately.

"4. The milk should be sold in two to six hours after bottling, as the cream layer volume shrinks on standing.

"5. The milk should be held at 40° F. or below, for the cream shrinks in volume very markedly at 50° F. or above."

Whittaker *et al.*, (2) after a study of the effect of various operations in the milk plant on the resulting cream layer of the milk, reached the following conclusions:

"Milk heated to 143° F. for thirty minutes showed practically no decrease in the cream volume, and in some cases an increase resulted.

"Pasteurization at 145° to 146° F. for thirty minutes reduced the cream volume an average of approximately 8 per cent, with considerable variations above and below.

"Pasteurization at approximately 148° F. for thirty minutes caused a decrease in cream volume of from 18.5 to 41.7 per cent, with an average decrease of approximately 31 per cent.

"The reduction in cream volume due to pasteurization at 145° to 146° F. was not so marked in the case of twenty-four- to thirty-six-hours-old milk as in fresh milk, owing to the fact that old milk does not show

so deep a cream volume before pasteurization as does fresh milk. Pasteurization of old market milk had a tendency to restore its creaming ability.

" The cream volume results showed only slight variations due to the different types of pasteurizing apparatus which were in use at the plants investigated, when factors in the processing other than heating and holding were not involved.

" At the particular plants investigated there was practically no difference in the cream-volume results from apparatus using a low-temperature heating medium as compared with that using a high-temperature medium, provided the time of heating was approximately the same.

" Only a slightly better cream volume was obtained in vat pasteurization when a low-temperature heating medium was forced through the coils by a direct-acting pump, as compared with the ordinary circulation of a heating medium of higher temperature.

" The tests to show the effect of agitation during the holding period were not uniform, but the tendency appeared to be slightly in favor of holding the milk without agitation during this period. Moderate agitation during the thirty-minute holding period apparently has no appreciable effect on the cream volume.

" Milk cooled in tank or vat pasteurizers from 145° to 50° F. showed a poor cream volume. Cooling milk in the tank or vat from 145° F. to 110° or 120°, and then cooling quickly to below 50° F. over a separate cooler, resulted in a good cream volume.

" The tests showed that cooling milk to a low temperature after pasteurization is necessary in order to obtain a good cream volume. Pasteurized milk cooled to below 45° F. showed a much better cream volume than that cooled to only 50° F. or above.

" Milk stored at 38° to 48° F. showed a much better cream volume than that stored at temperatures above 50° F. The difference in favor of the colder storage temperature was more marked in the case of the raw milk than in that of the pasteurized milk. The importance of low storage temperatures is often overlooked at milk plants.

" The cream volume of milk pasteurized at temperatures from 143° to 145° F. was greater after two or three hours' storage at low temperatures than in the original raw milk. This gradually decreased as the storage period was prolonged.

" The recreaming of raw milk decreased the cream volume, but after one recreaming the age of the milk was of more importance than the number of times it was recreamed.

" The recreaming of pasteurized milk had a detrimental effect on the cream volume. This has a practical significance at plants which bottle pasteurized milk after it has been allowed to cream.

" Pumping milk at temperatures between 60° and 120° F. reduced the cream volume to a slight extent in some cases. Pumping raw milk below 60° F. and pumping pasteurized milk at temperatures between 120° and 145° F. with the four types of pumps used had practically no effect on the cream volume.

" Allowing milk to stand or to be agitated for fifteen minutes or more at temperatures between 60° and 110° F. had generally a detrimental

effect on the cream volume. This was more pronounced with milk that was being cooled from the pasteurization temperature than with that which was being heated.

"Holding or agitating milk at a temperature of 145° F. had considerably less effect on the cream volume than at temperatures between 60° and 110° F.

"Clarifying milk at temperatures between 60° and 65° F. had only a slight effect on the cream volume, though there was a considerable decrease when the milk was clarified at temperatures above 80° F.

"Filtering hot milk had practically no effect on the cream volume.

"It is evident that a material decrease in the cream volume of the finished product may result from the accumulation of slight decreases brought about by various steps in the process; therefore it is important to minimize as much as possible the decrease in each step.

"The various shapes of bottles caused a great difference in the apparent cream volume."

REFERENCES

(1) Dahlberg, A. C., and Marquardt, J. C., The Creaming of Raw and Pasteurized Milk. N. Y. Agri. Exp. Sta. Tech. Bul. 157, 1929.

(2) Whittaker, H. A., Archibald, R. W., Shere, L., and Clement, C. E., Effect of Various Factors on the Creaming Ability of Market Milk. U. S. Dept. Agri. Bul. 1344, 1925.

(3) Clement, C. E., Le Fevre, P. E., Bain, J. B., and Grant, F. M., Effect of Milk Plant Arrangement and Methods of Operation on Labor Requirements. U. S. Dept. Agri. Tech. Bul. 153, 1929.

(4) Clement, C. E., and Grant, F. M., Equipment for City Milk Plants. U. S. Dept. Agri. Cir. 99, 1929.

Parker, H. N., City Milk Supply, 1917.

Ayers, S. H., The Present Status of Pasteurization of Milk. U. S. Dept. Agri. Bul. 342.

Ayers, S. H., The Pasteurization of Milk. U. S. Dept. Agri. B. A. I. Cir. 184, 1912.

Clement, C. E., Milk Plant Operation. U. S. Dept. Agri. Bul. 973, 1923.

Kilbourne, Chas. H., The Pasteurization of Milk from the Practical Viewpoint, 1916.

Pasteurization of Milk in the Final Package. Dairy Section, Iowa Agri. Exp. Sta., 1914.

Milk Plant Letters, U. S. Dept. Agri., Bur. Dairy Ind.

Trout, G. M., Cream Line Studies in Market Milk. W. Va. Agri. Exp. Sta. Bul. 229, 1930.

Harding, H. A., Effect of Temperature of Pasteurization on the Creaming Ability of Milk. Ill. Agri. Exp. Sta. Bul. 237, 1921.

Reid, Wm. H. E., The Effect of Different Pasteurization Temperatures on Several of the Physical Properties of Milk. Mo. Agri. Exp. Sta. Bul. 126, 1929.

CHAPTER XXI

SPECIAL PRACTICES

STANDARDIZING MILK AND CREAM

"STANDARDIZING" is the mixing together of milk or cream of different chemical compositions in order to secure milk or cream of a uniform, desired composition. The usual adjustment relates only to butterfat, but sometimes solids-not-fat are also considered. Let us take, for example, milk of different fat percentages. It is apparent that if equal quantities of 3 per cent and 4 per cent milk are mixed, the mixture will contain 3.5 per cent fat.

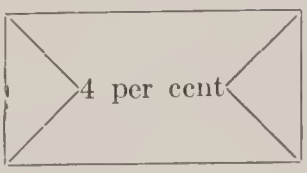
100 pounds 3 per cent milk contain..... 3 pounds fat
100 " 4 per cent milk contain..... 4 " "

200 pounds of mixture contain..... 7 pounds fat

2.00) 7.00 (3.5 per cent fat in mixture
6 00
1 000
1 000

The Rectangle Method.—Dr. R. A. Pearson devised a "rectangle" method, whereby milk or cream may be readily standardized. To use this method, draw a rectangle and write in the center the percentage of fat desired in the mixture. At the upper left-hand corner write the percentage of fat in one of the substances to be used in standardizing, and at the lower left-hand corner, the fat percentage of the other substance. Working diagonally across the square, subtract the smaller number from the larger and record the differences at opposite corners. The amount of each substance to be used will be found to the right of the rectangle in a horizontal plane with the fat percentage of the substance.

For example, it is desired to use 3 per cent milk and 6 per cent milk to make a mixture containing 4 per cent fat. Thus:



2 parts of 3 per cent milk, $2\times3=6$.

1 part of 6 per cent milk, $1\times6=6$.

$3\overline{)12}$

4%.

In this example, 2 parts of 3 per cent milk and 1 part of 6 per cent milk will give a mixture containing 4 per cent fat.

If a given quantity, say 100 pounds, of the mixture is desired, use the following formula:

$\frac{2}{3}\times100=$ pounds of 3 per cent milk = 66.67 pounds of 3 per cent milk
$\frac{1}{3}\times100=$ pounds of 6 per cent milk = 33.33 pounds of 6 per cent milk

100.00 pounds of 4 per cent milk

Milk which is below city standard for fat is sometimes standardized by the addition of cream, to bring it up to legal requirements. In other cases, milk high in fat is standardized by the addition of skim milk, to lower the fat percentage. The authors do not wish to advise either of these two practices, as both of them are illegal in many places.

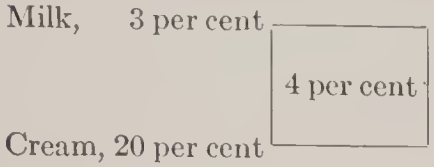
FOOD VALUE OF STANDARDIZED MILK

Standardizing with cream gives a lower food value than is found in normal milk of the same final fat percentage, while standardizing with skim milk gives a higher food value.

Suppose for instance, that 5 per cent milk is to be standardized down to 4 per cent by the addition of skim milk; and 3 per cent milk is to be standardized up to 4 per cent by the addition of 20 per cent cream. Normal milk and cream have approximately the following analyses:

	Fat.	Solids-not-fat.
20 per cent cream	20	7.15
3 per cent milk	3	8.33
4 per cent milk	4	8.79
5 per cent milk	5	9.10
Skim milk	..	9.25

First, consider upward standardization.



16 parts × 8.33 solids-not-fat = 133.28

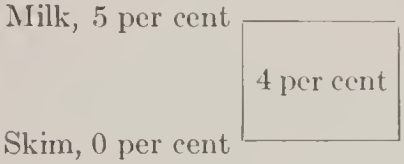
1 part × 7.15 solids-not-fat = 7.15

17 parts

17)140.43

8.26 per cent s.-n.-f.

It can be seen that the resultant mixture will contain 4 per cent fat and 8.26 per cent solids-not-fat, while normal milk contains 4 per cent fat and 8.78 per cent solids-not-fat. Now, let us standardize 5 per cent milk down to 4 per cent by adding skim milk.



4 parts × 9.10 solids-not-fat = 36.40

1 part × 9.25 solids-not-fat = 9.25

5 parts

5)45.65

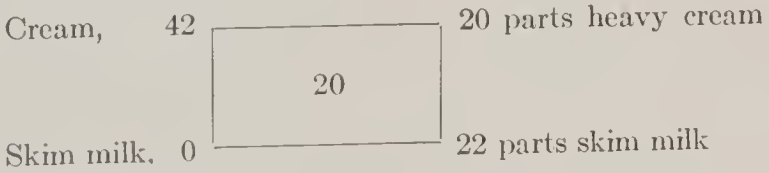
9.13 per cent

The standardized 4 per cent milk in this case has 9.13 per cent solids-not-fat, compared to 8.79 per cent in normal 4 per cent milk.

Standardizing Cream.—There are three ways in which heavy cream may be standardized to a lighter grade: first, by the addition of skim milk; second, by the addition of whole milk; and third, by the addition of a " lighter " or less rich cream. Although the same principle is used, illustrations of all three methods will be given, the rectangle method, devised by Pearson, being used in each case.

I

To make 20 per cent cream from 42 per cent cream and skim milk:



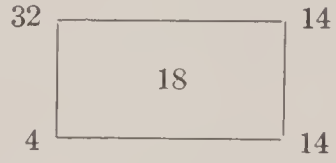
From this diagram it is seen that 20 parts of 42 per cent cream and 22 parts of skim milk will produce a 20 per cent cream. If a given quantity, say 25 pounds, of 20 per cent cream is desired, the following formula should be used:

$\frac{20}{42} \times 25 =$ heavy cream $\qquad \frac{22}{42} \times 25 =$ skim milk.

This gives 11.9 pounds of heavy cream and 13.1 of skim milk. (The factor 42 is obtained by adding the total number of parts, as 20 plus 22.)

II

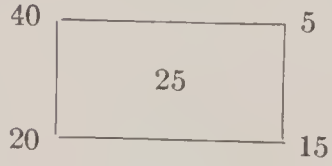
To make 40 pounds of 18 per cent cream from 32 per cent cream and 4 per cent milk:



Or, equal weights of 32 per cent cream and 4 per cent milk will make 18 per cent cream.

III

To make 35 pounds of 25 per cent cream from 40 per cent cream and 20 per cent cream:



Therefore, use $\frac{5}{20} \times 35$ pounds of 40 per cent cream and $\frac{15}{20} \times 35$ pounds of 20 per cent cream. This equals 8.75 pounds of 40 per cent cream and 26.25 pounds of 20 per cent cream.

In standardizing, the following points should be carefully observed:

1. The milk and cream to be used in standardizing should be accurately tested.
2. Great care should be exercised in figuring the quantity to be used.
3. All vats, stirrers, etc., which come into contact with the milk or cream should be sterilized. Standardization should be done in a clean room, and the product should be guarded from fly and dust contamination.
4. It is important to see that the materials used are thoroughly mixed.
5. It is a wise precaution to make a test of the finished product to see that no mistake has been made.

CLARIFICATION

Clarifiers are used in milk plants to remove the visible dirt. Clarification will not, as is sometimes supposed, reduce the bacterial count of the milk.

Effect of Clarification on the Bacterial Count.—McInerney, of Cornell University, made an extensive study on the effect of clarification on the bacterial content of fresh milk. The results are shown in Table 98.

TABLE 98

EFFECT OF CLARIFICATION ON THE BACTERIAL CONTENT OF FRESH MILK *

Experiment.	Bacteria per Cubic Centimeter.		Increase	
	In Unclarified Milk.	In Clarified Milk.	Per Cubic Centimeter.	Per Cent.
1	700	1,600	900	128.57
2	2,300	2,400	100	43.48
3	641	1,825	1,184	184.71
4	1,250	2,483	1,233	98.64
5	563	2,900	2,337	415.10
6	1,400	1,475	75	5.36
7	525	1,100	575	109.52
8	6,000	9,000	3,000	50.00
9	10,000	30,000	20,000	200.00
10	1,100	1,400	300	27.27
11	5,000	10,000	5,000	100.00
12	4,000	4,000	0	
13	4,500	18,000	13,500	300.00
14	3,600	5,000	1,400	38.89
15	2,100	2,600	500	23.81
16	3,650	5,550	1,900	52.05
17	7,000	20,000	13,000	185.71
18	5,480	12,125	6,645	121.26
19	10,000	13,000	3,000	30.00
20	11,320	13,600	2,280	20.14
21	4,280	8,000	3,720	86.91
22	4,600	4,250	−350	
23	1,600	4,100	2,500	156.25
24	15,000	22,000	7,000	46.67
25	53,000	71,500	18,500	34.90
26	60,000	156,000	96,000	160.00
27	5,675	5,775	100	1.76
28	10,200	11,000	800	7.84
Average...	8,410	15,739	7,329	87.15

* Cornell Bulletin No. 389.

"The initial count was less than 10,000 bacteria per cubic centimeter in twenty-one of the samples, while after clarification only seventeen

showed a count of less than 10,000 bacteria per cubic centimeter. In one sample the number of bacteria per cubic centimeter remained the same after clarification and in one there was a decrease. The percentage of increase ranged from 1.76 to 415.10, the average being 87.15. According to the figures, if a milk with a very low bacterial count is clarified, even though the clarified milk shows an increase of 100 per cent in the bacterial count, this count in the end would not necessarily mean a high-count milk."

The effect of clarification on the bacterial content of old and dirty milk is shown in Table 99

TABLE 99

EFFECT OF CLARIFICATION ON THE BACTERIAL CONTENT OF OLD AND DIRTY MILK *

Experiment.	Bacteria per Cubic Centimeter.		Increase.	
	In Unclarified Milk.	In Clarified Milk.	Per Cubic Centimeter.	Per Cent.
1	830,000	13,900,000	13,070,000	1574.70
2	40,000	110,000	70,000	175.00
3	494,000	6,400,000	5,906,000	1195.55
4	133,500	197,500	64,000	47.94
5	15,000,000	30,000,000	15,000,000	100.00
6	37,800,000	40,000,000	2,200,000	5.82
7	1,500,000	3,200,000	1,700,000	113.33
8	370,000	643,000	273,000	73.78
9	600,000	1,300,000	700,000	116.67
10	55,000	175,000	120,000	218.18
11	19,000,000	160,000,000	141,000,000	742.10
12	248,000	425,000	177,000	71.37
13	558,750	1,863,300	1,304,550	233.48
14	190,000	237,000	47,000	24.74
15	83,400,000	91,030,000	7,630,000	9.15
16	1,590,000	1,831,000	241,000	15.16
17	4,420,000	5,700,000	1,280,000	28.96
Average...	9,778,191	21,000,694	11,222,503	114.77

* Cornell Bulletin No. 389.

"The milk was obtained from sources not under city inspection, and the conditions under which it was produced and handled were not considered sanitary. Some milk producers carelessly allow insoluble dirt

to fall into the milk, thinking that it can be removed by straining or by clarification. It was to test this point that studies were made on the effect of clarification on the germ content of dirty milk."

"The development of bacteria in clarified milk was compared with their development in unclarified milk. Samples of clean milk and of dirty milk, both before and after clarification, were kept at a temperature of 14.4° C. for twenty-four hours and then plated to determine the number of bacteria present." The results of this work are shown in Tables 100 and 101.

TABLE 100

DEVELOPMENT OF BACTERIA IN CLEAN MILK AFTER BEING HELD FOR 24 HOURS AT 14.4° C.*

Experiment	Bacteria per Cubic Centimeter in Unclarified Milk.				Bacteria per Cubic Centimeter in Clarified Milk.			
	Fresh	After 24 Hours at 14.4° C.	Increase.		Fresh	After 24 Hours at 14.4° C.	Increase.	
			Per Cubic Centimeter.	Per Cent.			Per Cubic Centimeter.	Per Cent.
1	4,000	10,000	6,000	150.00	8,000	30,000	22,000	275.00
2	5,500	42,000	36,500	663.64	12,000	40,000	28,000	233.33
3	4,000	10,000	6,000	150.00	4,000	20,000	16,000	400.00
4	4,500	18,000	13,500	300.00	6,000	29,000	23,000	383.33
5	3,600	602,000	598,400	16,622.22	5,000	785,000	780,000	15,600.00
6	2,350	221,000	218,650	9,304.25	3,350	175,000	171,650	5,123.88
7	3,650	97,500	93,850	2,571.23	5,550	279,000	273,450	4,927.03
8	7,000	774,000	767,000	10,957.14	16,000	805,000	789,000	4,931.25
9	5,480	248,000	242,520	4,425.55	12,125	433,300	421,175	3,472.61
10	7,550	69,733	62,183	823.61	7,500	454,000	456,500	6,086.67
11	15,000	22,000	7,000	46.67	26,000	27,000	1,000	3.85
12	53,000	380,000	327,000	616.98	114,000	114,000		
13	60,000	265,000	205,000	341.67	181,500	295,000	113,500	62.53
14	5,675	9,500	3,825	67.40	5,775	5,900	125	2.16
15	10,200	55,000	44,800	439.21	11,000	67,006	56,006	509.14
Average	12,767	188,249	175,482	1,374.50	27,853	237,947	210,094	754.29

* Cornell Bulletin No. 389.

"In the case of the clean milk (Table 100), it was found that in nine of the fifteen tests made there was a greater percentage of increase in bacterial content in the unclarified milk than in the clarified milk, the average percentage of increase being 1374.50 for the former and 754.29 for the latter. With the dirty milk (Table 101) there was a more uniform increase in the number of bacteria per cubic centimeter in the clarified milk as compared with the unclarified milk, and the average percentage

of increase was 1691.86 for the unclarified milk and 431.50 for the clarified milk."

TABLE 101

DEVELOPMENT OF BACTERIA IN DIRTY MILK AFTER BEING HELD FOR 24 HOURS AT 14.4° C.*

Exp.	Bacteria per Cubic Centimeter in Unclarified Milk.				Bacteria per Cubic Centimeter in Clarified Milk.			
	Fresh.	After 24 Hours at 14.4° C.	Increase.		Fresh.	After 24 Hours at 14.4° C.	Increase.	
			Per Cubic Centimeter.	Per Cent.			Per Cubic Centimeter.	Per Cent.
1	1,500,000	12,000,000	10,500,000	700.00	3,200,000	24,000,000	20,800,000	650 00
2	370,000	8,000,000	7,630,000	2,062.16	643,000	20,000,000	19,357,000	2,010.42
3	600,000	23,000,000	22,400,000	3,733.33	1,300,000	45,000,000	43,700,000	3,361.54
4	47,000	1,124,000	1,077,000	2,291.49	170,000	1,024,000	854,000	502.35
5	12,000,000	33,000,000	21,000,000	175.00	18,000,000	77,000,000	59,000,000	327.78
6	95,000	1,450,000	1,355,000	1,426.31	100,000	2,070,000	1,970,000	1,970.00
7	190,000	30,000,000	29,810,000	15,689.47	180,000	30,000,000	29,820,000	16,566.67
8	40,000	1,000,000	860,000	2,400.00	70,000	4,800,000	4,730,000	6,757.14
9	33,000	1,800,000	1,767,000	5,354.54	48,000	1,700,000	1,752,000	3,441.67
10	133,000	7,500,000	7,367,000	5,539.10	187,000	12,500,000	12,313,000	6,584.49
11	48,500	1,124,000	1,075,500	2,217.52	165,500	1,022,000	856,500	517.52
12	12,000,000	335,000,000	323,000,000	2,691.67	180,000,000	800,000,000	620,000,000	344.44
13	21,500	2,800,000	2,778,500	12,923.25	36,500	3,400,000	3,363,500	9,215.07
14	95,000	1,450,000	1,355,000	1,426.31	100,000	2,070,000	1,970,000	1,970.00
15	170,000	7,800,000	7,630,000	4,488.23	78,250	22,000,000	21,921,750	28,015.01
16	2,350	220,000	217,650	9,261.70	3,350	165,000	161,650	4,825.37
17	190,000	30,000,000	29,810,000	15,689.47	179,000	30,000,000	29,821,000	16,659.78
18	37,000	1,095,000	1,058,000	2,859.46	70,000	4,800,000	4,730,000	6,757.14
19	133,500	540,000	406,500	304.49	197,500	2,160,000	1,962,500	993.67
20	494,000	6,400,000	5,906,000	1,195.55	1,200,000	10,800,000	9,600,000	800.00
Av.	1,409,993	25,265,150	23,855,157	1,691.86	10,296,405	54,725,550	44,429,145	431.50

* Cornell Bulletin No. 389.

Effect of Clarification on the Composition of Milk.—"The large amount of slime deposited in the clarifier bowl seemed to indicate that clarification might reduce the total solids of the milk, and possibly the fat content, and experiments were made to determine whether this was the case. The amounts of slime obtained from different quantities of milk when passed through the clarifier are shown in Table 102."

McInerney's conclusions are as follows:

"When fresh milk is clarified, although the bacterial count may be increased 100 per cent, the final count is likely to be not over 10,000 bacteria per cubic centimeter, the average percentage of increase in these experiments being 87.15.

"The percentage of increase in bacterial content by clarification is greater in the case of old milk than in the case of fresh milk. This is probably due to the high initial count in old milk. In these experiments the average percentage of increase for the old milk was 114.77.

TABLE 102

AMOUNTS OF SLIME OBTAINED FROM DIFFERENT QUANTITIES OF MILK *

Experiment.	Milk Used. (Ounces.)	Slime Obtained (Ounces.)	Per Cent of Slime.
1	89,088	5.64	0.0063
2	82,964	7.65	0.0092
3	87,680	6.98	0.0080
4	88,960	6.49	0.0073
5	89,088	6.80	0.0076
6	84,480	12.62	0.0149
7	84,480	8.25	0.0098
8	84,480	6.45	0.0076

* Cornell Bulletin No. 389.

TABLE 103

CHEMICAL ANALYSIS OF CLARIFIER SLIME *

Experiment.	Fat, Per Cent.	Water, Per Cent.	Total Solids, Per Cent.	Ash, Per Cent.	Nitrogen, Per Cent.	Casein, Per Cent.
1	4.0	70.13	29.87	4.17	0.43	2.74
2	5.0	71.86	28.14	2.73	0.23	1.46
3	3.4	70.04	29.96	3.81	0.71	4.52
4	3.2	69.92	30.08	3.00	0.14	0.89
5	4.0	75.50	24.50	2.74	0.31	1.97
6	5.0	71.01	28.99	3.36	0.10	0.63
7	3.7	71.35	28.65	2.59	0.49	3.12
8	4.0	70.87	29.13	2.83	0.27	1.72
Average....	4.0	71.33	28.67	3.15	0.33	2.13

* Cornell Bulletin No. 389.

"Bacteria increase more rapidly in unclarified milk than in clarified milk.

"The fat content before and after clarification is practically the same.

"The percentage of total solids is slightly reduced by clarification. This is probably due to the slime removed.

"The development of acidity is slightly more rapid in clarified milk than in unclarified milk.

"The keeping qualities of milk remain about the same after clarification as before.

"About 99 per cent of the insoluble dirt in milk is removed by clarification.

"The volume of cream that is separated by gravity is reduced from 2 to 3 per cent by clarification. This is probably due to the agitation of the milk in passing through the clarifier."

HOMOGENIZATION

The homogenizer is used for the purpose of breaking up the fat globules and making the milk or cream of more uniform consistency. The milk or cream is forced, under a pressure of 1000 to 3000 pounds per square inch, through a very small opening. After milk or cream has gone through the homogenizer the fat will not readily separate from the milk serum, as the fat globules have been so reduced in size that they are not buoyant enough to rise. It is impossible to whip or churn cream homogenized at high pressures.

Types of Homogenizers.—There are at least two types of homogenizers, one of which consists of a single-acting triplex pump, each cylinder having a suction and a discharge valve. In the discharge pipe is placed a special valve which is somewhat similar to a safety or relief valve. This valve, which is made of agate and fits against a carefully ground valve seat, is held closed by a spring and may be set to open at a definite pressure. The milk is forced through the ground surfaces of this valve and the fat globules are thus broken up into fine particles.

The second type of homogenizer is similar to the first, except that the milk, instead of being forced between an agate valve and its seat, is passed through a series of disks made of Monel metal. These disks are held rigidly in position, and as the milk passes through the small openings the globules are broken up.

Uses of the Homogenizer.—In the market milk business, the homogenizer is used principally in the preparation of sweet cream. Cream that has been homogenized is of a smooth and uniform body, the fat does not separate readily, and the cream appears to have a higher percentage of butter-fat than it really has. For this reason homogenized cream should be labeled as such.

When milk or cream is reconstructed, or manufactured from butter and skim milk, condensed milk or milk powder, the mixture is run through the homogenizer and the resulting cream or milk has the appearance of the natural fresh product.

The homogenizer is widely used in the ice-cream business, for homogenizing both the cream and the mix, a smooth and uniform-bodied ice-cream being the result.

Operation of the Homogenizer.—The cream or milk to be homogenized should first be heated to about 120° F. When the milk or cream is pasteurized it is pre-cooled from the pasteurizing temperature to about 120° F., before going to the homogenizer. It is important that the pressure used be not too high. For ordinary market cream, 1500 to 2500 pounds per square inch is sufficient. As the milk or cream comes from the homogenizer it is passed over a cooler and cooled to 45° or 50° F.

After the milk or cream has passed through the homogenizer, water should be run through it before the machine is shut down. This should be followed by a solution of warm water and washing powder, then hot water and steam. As is the case with all other milk-handling equipment, the homogenizer must be kept scrupulously clean.

Viscolizer.—The viscolizer is a machine similar to the homogenizer, operating under a similar pressure and supposed to do similar work. The cost of the viscolizer is considerably less than that of the homogenizer, as the materials used are not so expensive as are those used in the other machines.

EMULSIFICATION

Milk and cream are emulsified for about the same purpose as they are homogenized or viscolized, but in this process the fat globules are not broken up into such fine particles as when the homogenizer is used, and the resulting mixture is not so stable and uniform.

There are at least two types of machines for this purpose, made by different manufacturers and called by them emulsors, emulsers, or emulsifiers. The first type looks like the ordinary cream separator and produces cream by the "centrifugal re-emulsification of the component parts." The other type works somewhat like an injector, and is described by its manufacturers as follows: "Steam enters at the end of the emulser proper and passes through a small nozzle into a larger tube and in that way sucks up the ingredients that are to be emulsified and discharges them with great force through this tube into a cone made of intricate, fine wire mesh." These machines are used primarily in the reconstruction of cream from butter and skim milk, milk powder or condensed milk.

REFERENCES

Milk Plant Letters, U. S. Dept. Agri., Dairy Division.
Parker, H. N., The City Milk Supply.
Mortensen, Management of Dairy Plants, 1921.
McInerney, Clarification of Milk. Cornell University Agri. Exp. Sta. Bul. 389.
Clement, C. E., and Grant, F. M., Equipment for City Milk Plants. U. S. Dept Agri. Cir. 99, 1929.

CHAPTER XXII

MECHANICAL REFRIGERATION

Artificial or mechanical refrigeration in milk plants was formerly considered expensive and impractical, especially in small plants. In recent years, however, milk dealers quite generally have adopted mechanical refrigeration. The following are some of the advantages of mechanical refrigeration as compared with the use of ice:

1. There is less work in handling.
2. The cost is usually less.
3. Waste is practically eliminated.
4. Mechanical refrigeration is much cleaner and more sanitary, as there is no mold or slop as in the case of ice.
5. A much drier atmosphere can be maintained in the storage rooms.
6. Much lower temperatures can be obtained.
7. Temperature can be more accurately controlled.

CONDITIONS TO BE CONSIDERED

In deciding whether to use ice or mechanical refrigeration, the comparative cost is, of course, the must important factor. However, it should be remarked that the mechanical refrigeration system is often of more value than can be estimated, because of the better results obtained. In determining the comparative cost of the two systems it is necessary to consider such items as the price of ice, quantity required, labor in handling, the initial cost of a mechanical system and the cost of operation. The cost of ice will, of course, depend to a large extent on the locality. The cost of operation of a mechanical system is small, the cost of power to run the compressor being the principal item. The operation of the system is simple and requires very little attention; often the operator starts the machine in the morning and pays no further attention to it until he shuts it down at night. However, the man who has charge of the system should be experienced, as it is not good economy to trust the operation of this machine, even though it is simple, to a novice. It is essential that the machine be operated efficiently at all times and be kept in good working order, and, should

anything happen, someone must be on the ground who has mechanical ability and experience, or great losses may result. Nevertheless, in most milk plants the services of a mechanically trained man are required even if artificial refrigeration is not used, so that usually the operation of the refrigerating system does not necessitate the employment of an additional man.

PRINCIPLE OF MECHANICAL REFRIGERATION

The principle involved in mechanical refrigeration is that when a substance passes from a liquid to a gaseous state the change is accompanied by the absorption of heat, called "latent heat." The coolness produced by the rapid evaporation of perspiration from the body is familiar to all. In mechanical refrigeration, the rapid evaporation of the liquid refrigerant into a gas absorbs the surrounding heat and produces cold.

Several systems of artificial refrigeration are in use, and several different chemicals are used as refrigerating media; the compression and absorption systems are the most common, and ammonia, carbon-dioxide and sulphur dioxide are the chemicals most frequently used. The system most commonly found in milk plants, namely, the compression system in which ammonia is used as the refrigerating medium, will be the only one considered here.

COMPRESSION SYSTEM

There are three principal steps in the operation of the compression system of mechanical refrigeration:

1. Compression of the ammonia gas.
2. Condensation of the ammonia gas.
3. Expansion of the liquefied gas into a vapor.

(1) The ammonia gas is drawn into the suction side of the compressor, compressed and discharged under a pressure of 125 to 175 pounds per square inch on the return stroke of the compressor. The compressor is simply a specially designed pump which takes the gas at a low pressure and compresses it, thus reducing its volume and increasing its temperature.

(2) From the discharge side of the compressor the gas is forced into the condenser. Sufficient heat is removed to change the gas to a liquid, but it is still under high pressure and is ready to expand into a gaseous form and absorb heat in the process. The condenser consists simply of coils of pipes over which cold water flows, thus reducing the temperature of the ammonia gas passing through the pipe. This

water can later be used in the plant for other purposes. The condenser is often put on the roof of the building, the water flowing over it from a tank, by gravity. An advantage of locating it on the roof is that during cold weather the cooling water will be cooled by the outside air.

In small plants, the condenser often consists of a pipe within a pipe. The cooling water passes through the inner tube while the gas coming from the compressor passes through the outer tube. This type of compressor is compact, requiring small space, and in small plants is usually placed in the room with the compressor or in an adjoining room.

(3) After the ammonia has been liquefied by the condenser, it first passes to a liquid receiver; thence the liquid, still under pressure, is passed through what is termed an expansion valve. This valve can be adjusted so as to allow the liquid to pass through in very small quantities. By thus passing through a very small opening under high pressure, into the cooling coils where the pressure is low (these coils being connected with the suction side of the compressor), the liquid refrigerant is again changed to the gaseous state. In reality, the passing of the liquid through the small opening to the cooling coils, where the lower pressure is maintained, causes it to boil, at a temperature low enough to absorb heat from the surrounding air. The expanded gas circulates through these cooling coils, takes up the heat in the surrounding air, and cools the room. From the cooling coils the ammonia gas is drawn back into the compressor on the suction stroke, and the cycle is repeated.

Methods of Utilizing Refrigeration.—There are two common methods of transferring the cold produced by the refrigerating machinery above described to the milk storage rooms, milk cooler or other place at which cooling is to be accomplished, namely:

1. Direct expansion system.
2. Brine system.

(1) In the direct expansion system, the coils in which the refrigerant is evaporated are placed in the room to be cooled. The heat absorbed by the change of the refrigerant to the gaseous state is thus absorbed directly from the air in the room. In the case of milk coolers described on page 284, the liquefied ammonia is expanded directly into the cooling coils, and the change to the gaseous state absorbs the heat from the milk flowing over the outside of the cooler.

(2) In the brine system, the coils into which the refrigerant is expanded are placed in a tank called a brine tank. This tank contains a solution of calcium chloride or of common salt. The brine solution is used in preference to clear water because it has a low freezing point, so that a low temperature can be maintained without danger of

freezing the solution. The brine tank is often placed overhead in the cold storage room and thus directly helps to keep the room cold. The brine from this tank is passed through coils in the room and also through the coils in the lower section of the milk cooler. After passing through these coils, it is returned to the tank, its temperature is again reduced and the process is continued.

Table 80, page 286, shows the number of plants using the two systems of cooling the milk, according to a survey made by the United States Department of Agriculture.

One of the chief advantages of the brine system is that the brine may be kept cold by running the compressor for a few hours during the day. The cold is thus stored up and used when needed. This is especially important in small plants which are operated only six or eight hours a day, as in this way the work of refrigeration may go on after the plant is shut down. In large plants where a large quantity of refrigeration is needed, and it is necessary to run the machine practically continuously during the hot weather, the direct expansion system would be the most feasible. This system is simpler to operate, and requires less initial expenditure, and there is less loss of refrigeration in the transfer of the cooling medium to the place which is to be cooled. The initial cost of installing the brine system is, of course, greater, as besides the compressor, condenser, and other units required in the direct expansion system, the brine system also requires a brine tank, brine coils and brine pump.

FIG. 121.—Compressor in refrigerating plant.

Strength of Brine.—The degree of concentration of the brine solution will depend on the temperature desired. A stronger solution will be needed for low temperatures, in order to prevent freezing. Too much concentration, however, is to be avoided, as a solution that is too strong is likely to clog the pipes, and can absorb less heat, as its specific heat is lower.

Size of Compressor—The size of machine required will depend on the quantity of milk handled and the methods used at the particular plant.

Where all the milk is to be held in storage, more refrigeration capacity will, of course, be required than where some of the milk is sent out on the delivery wagons immediately after bottling.

The graph below is from United States Department of Agriculture Bulletin No. 98, by Bowen; (1) the cost figures are, of course, lower than present costs, the bulletin having been issued in 1914.

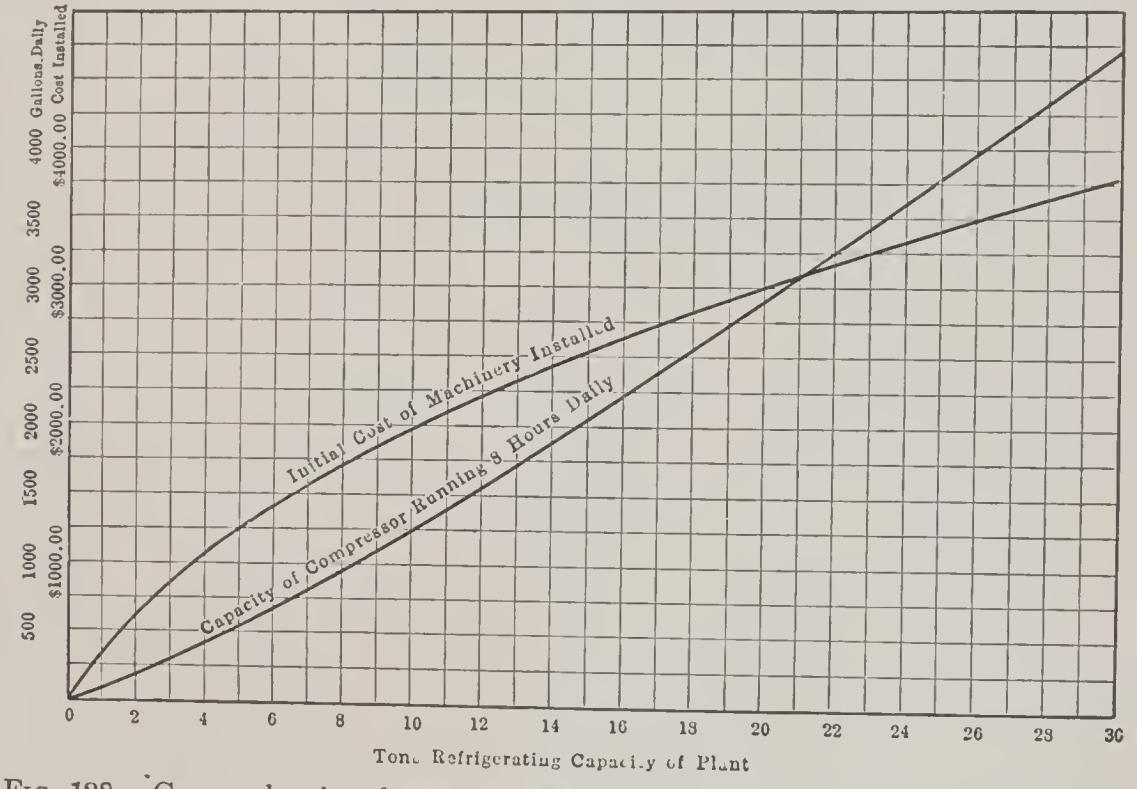

500 1000 1500 2000 2500 3000 3500 4000 Gallons Daily
$1000.00 $2000.00 $3000.00 $4000.00 Cost Installed
Initial Cost of Machinery Installed
Capacity of Compressor Running 8 Hours Daily
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Tons Refrigerating Capacity of Plant

FIG. 122.—Curves showing the approximate size and cost of belt-driven refrigerating equipment for milk plants of various sizes. (1)

INDIRECT SYSTEM OF REFRIGERATION

In some large, modern milk plants, an indirect system of cooling is used. With this system the cooling coils are located in a compartment or room outside of the room to be cooled. Air is forced over these coils, by means of a fan, into the cold-storage room. This cooled air is forced into the room through flues, which have openings into the room. The warmer air in the cold room passes out through flues, back to the bunker room, in which the cooling coils are located, and after being cooled is again blown through flues into the room.

One of the main advantages of this plan is that it acts as a ventilating system as well as a cooling system, resulting in a pure, dry atmosphere in the room. In some cases the air is completely changed every six minutes.

REQUIREMENTS OF REFRIGERATING EQUIPMENT FOR MILK PLANTS

Bowen, in United States Department of Agriculture Bulletin No. 98, gives the following as the principal requirements of a refrigerating system for use in milk plants and creameries:

1. Should be reasonable in cost.
2. Should be economical to operate.
3. Should be reasonably secure from breakdown.
4. Should produce cool and dry air in storage room.
5. Should produce lower temperatures than ice.
6. Should give perfect control of temperatures.
7. Should be simple in construction and operation as to require little attention and be successfully operated by any careful person without any special mechanical or engineering skill.
8. Should occupy little space.

CARE OF REFRIGERATING MACHINERY

Although the operation of refrigerating machinery is simple, like any other machinery it must be given good care. The following directions for the care of the refrigerating machine are given by Bowen, (1) in United States Department of Agriculture Bulletin No. 98:

"In caring for machinery of any kind, one of the most important things is cleanliness, and especially is this true of refrigerating apparatus. If the cooling and condensing surfaces are allowed to become coated even slightly, their heat-transferring efficiency will be lowered materially.

"Where atmospheric condensers are used, it is an easy matter, when the surfaces become coated, to clean them with a brush, provided the coating is not of the nature of a scale. If the substance is hard, it will be necessary to employ files or steel scrapers in removing the scale. In double-pipe condensers and coolers it is not such an easy matter to clean them, as it is necessary to take off a return bend from the end of the condenser or cooler in order to examine or clean them. This should be done frequently, and if the inner pipe is found to be coated with a soft substance it can be removed by the aid of an ordinary flue brush. If, however, the coating is in the form of scale, it will be necessary to bore it out on a lathe or tube-boring machine.

"The life and satisfactory operation of all mechanical apparatus are dependent on proper care as well as on the original design. It is therefore necessary that such apparatus should receive frequent and careful inspection and prompt correction of all defects found. As cleanliness is essential for the satisfactory operation of machinery of all kinds, the wearing parts of the machine should be kept free from dirt and grit and the oilways open, well lubricated, and adjusted. The clearance of the pistons should be adjusted to a minimum, both in the steam and compressor cylinders.

"In operating an ammonia plant the gages should be carefully watched, as they are the indicators of the work being done. The suction or low-pressure gage is controlled to a great extent by the expansion valve in the liquid line; consequently, opening it will increase the low pressure, as the more the valve is opened the more gas will be pumped, providing the machine is run at a constant speed. If the speed of the compressor is increased, the amount of work will be proportionately increased provided the valves are large enough to handle the additional amount of gas, and vice versa. If the expansion valve is opened too wide for the speed at which the machine is running, the suction pipe will frost back to the machine and even the top of the compressor may become covered with frost. For satisfactory operation in a refrigerating plant a slight frost should cover the suction pipe close to the machine.

"If the temperature of the brine in the cooling room is high, a corresponding high back pressure should be carried, and, on the other hand, a low brine temperature requires a low back pressure. Should a very low brine temperature be required, in addition to a low back pressure, the machine should be run at a faster speed, depending upon the relative capacity of the machine and the work to be done. It is necessary in the maintenance of low temperatures to keep the system free from air and deleterious gases, and plenty of cooling water should be supplied to the condenser while the plant is in operation.

"For small plants the receiver should be of suitable size to hold all the refrigerating medium in a liquid form. It is usually located just below the condenser, or as near to it as local conditions will allow, so that the liquefied gas may return to the receiver by gravity.

"In order that the amount of refrigerant contained in the system may be seen at a glance, the receiver should be provided with a glass gage similar to that placed on steam boilers to show the amount of water. This is especially true in small plants, where the attendant may not have had the necessary experience to enable him to judge of the amount of refrigerant in the system, and by observing the line of the liquid in the glass gage each time before starting up the compressor he will be able to note any loss of the refrigerant which he might not be able to do by other methods.

"Some manufacturers, however, object to placing a gage of this kind on the receiver, as they contend that there is a possibility of loss of refrigerant by the breaking of the glass, and perhaps some danger should anhydrous ammonia be the refrigerant used. There is little danger, however, as the pressure and temperature is nearly constant and automatic ball-stop valves may be used that will shut off the flow should the glass break.

"It should be distinctly understood, however, that the foregoing refers to new plants and not to old ones. Under no circumstances should air at high pressure be pumped directly into an old system after repairing, or into one that has been standing idle for some time, as an explosion is likely to occur, due to the vaporization of oil which may have lodged in the coils. The temperature of the air, when pumped into the system at a high pressure, is liable to exceed the flash point of the oil, resulting in an explosion.

"For the same reason it is also dangerous, especially in the case of small, fast-running machines, to allow too much air to enter when pumping out the compressor in case it becomes necessary to pack the stuffing box; for should the attendant neglect to purge the condenser after the operation, the air in the system will be carried along with the ammonia gas, necessitating a higher pressure and a consequent higher temperature than would otherwise be attained; and should the temperature in the system get too great, there is danger of the oil which may be deposited in the coils reaching a point where flashing will take place, which will result in an explosion.

"In small installations usually found in milk plants, creameries, and dairies the condensers are of small dimensions; consequently, they can not hold large quantities of excess air. Hence great care should be taken to thoroughly purge the system of air when starting up after pumping out the compressor, by blowing the air from the system. Manufacturers provide cocks for this purpose.

"In cleansing old plants or those that have been shut down for some time, from deposits of oil, it is a good plan to pump hot ammonia gas into the system. The gas should be taken from the line just before it enters the condenser. If taken from the top of the condenser, the gas will probably contain air and other impurities which would be liable to cause an explosion.

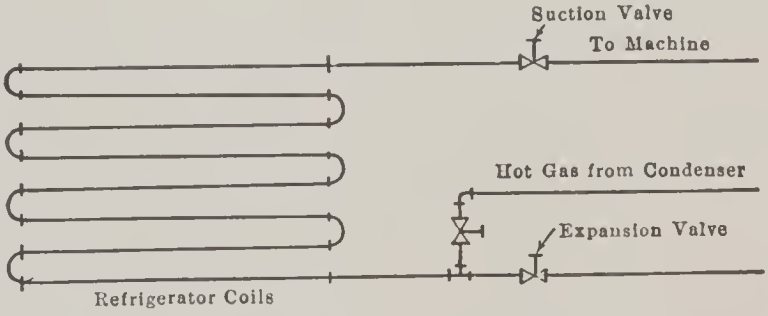


FIG. 123.—Conventional diagram of cooling system. (1)

"Referring to the conventional diagram, Fig. 123, the method of operation should be as follows: Connect a temporary pipe line with valve from the lowest part of the condenser or to the pipe line just before entering the condenser. Close the expansion valve and pump hot ammonia gas into the coils. Have the suction valve opened slightly and occasionally open it wide quickly to allow the oil to be carried out and deposited in the oil trap, from which it can be drawn off.

"Before starting up the plant care should be taken to see that all oil cups are filled and the oilways open, in order that all wearing surfaces may be well lubricated before the machine is started.

"To start.—(1) Turn the water on the condenser and water jacket, and open the discharge valve on the compressor; (2) start the machine slowly at first and after the machine is in motion and the pressures are at proper point open the suction valve on the compressor gradually; (3) open the expansion valve sufficiently to give the required back pressure and the machine is in full operation.

"To stop.—(1) Close the king valve which is between the receiver and the expansion valve and pump the low pressure to zero. This is considered better practice than closing the expansion valve each time the machine is stopped, thereby necessitating readjustment of the expansion valve upon starting up again; (2) open all drips and drains and shut down the machine; (3) close the suction and discharge valves, and all oil cups and water valves; (4) clean the machine thoroughly and examine all bolts and nuts to see that they are tight and see that the bearings are properly adjusted."

THE MILK STORAGE ROOM

The milk storage room must, as far as is possible, prevent the outside heat from passing through the walls, ceiling or floors into the room. For this purpose it must be well insulated. There is no suitable material that will entirely prevent the transmission of heat through it, but there are some that are better than others. The most common materials used are granulated cork, cork board, mineral wool, vegetable fiber, sawdust, etc., which are used as fillers in walls of wood, cement or masonry. One of the best materials is cork board, from 4 to 6 inches thick, finished on both the inside and the outside with cement.

FIG. 124.—Milk storage room.

The floors of the room should be of concrete placed solidly on the insulating material. The placing of the insulating material must be carefully done; each course of the material should be connected with the next and there should be no breaks.

The walls of the room should be exposed to the outside air as little as possible, and the room should therefore be located, as far as possible,

in the interior of the building. The side of the room that is exposed should preferably be on that side of the building which receives the least direct rays of the sun. As artificial light will be required, windows are not necessary; if windows are installed they should consist of four or more thicknesses, and the outside one should be painted to prevent the transmission of the heat from the sun's rays. If possible, the room should be so located that the milk may pass directly into it from the bottling room, and that it will, at the same time, be convenient for the loading of the delivery wagons. The door should swing outward to save both space and refrigeration, and the room should be as nearly square as is practicable. The size of the room will, of course, depend on the quantity of milk to be handled and the methods used. There should be room enough to store all the milk of one day's run and leave working space, but waste space should be avoided.

The following are the approximate sizes of milk storage rooms required for plants handling various quantities of bottled milk:

Quantity of Bottled Milk Handled.	Size of Room.
300 gallons.....	8× 8
500 "	10×10
1000 "	12×15
2000 "	18×20
4000 "	24×30

REFERENCES

(1) Bowen, John T., The Application of Refrigeration to the Handling of Milk, U. S. Dept. Agri. Bul. 98, 1914.

Mortensen, Martin, Management of Dairy Plants, 1921.

Clement, C. E., and Grant, F. M., Equipment for City Milk Plants. U. S. Dept Agri. Cir. 99, 1929.

CHAPTER XXIII

MILK DELIVERY

Milk is generally distributed by the dealer in one of two ways:

1. Direct to the consumer.
2. To stores, hotels, restaurants, etc., which, in turn, dispense it to the ultimate consumer.

Most of the milk delivered to the consumer or to stores is delivered in bottles, although in some cities, stores handle bulk milk. Bulk milk in cans is quite generally delivered to hotels and restaurants.

DELIVERY OF MILK THROUGH STORES

The delivery of milk through stores has recently attracted considerable attention, and has been pointed out by some investigators, as one of the means available for reducing the cost of milk distribution. It is questionable, however, whether the store can be used as a factor in reducing the cost of milk to the consumer. While in some cases the consumer can get milk cheaper when he goes to the store for it, more often the price of bottled milk at the store is the same as that of milk delivered at the consumer's door by the dealer.

Relative Economy of Delivery through Stores and Direct to the Consumer.—The margin that is allowed the store for handling milk varies in different cities from 1 to 3 cents per quart, but 2 cents doubtless represents the approximate difference of cost to the dealer between delivery to the consumer in small quantities and delivery to the stores in large quantities. Very few stores will care to provide refrigeration and attend to the selling of the milk for less than 2 cents per quart. Therefore, the price that the consumer must pay at the store is usually as high as that of milk delivered at his door, and in special instances, the price at the store is higher, even though the customer comes to the store for the milk.

Where only a part of the milk is handled through stores, the method tends to increase the cost of delivery on retail routes because it causes the customers on those routes to be more scattered. Doubtless, if all

milk were delivered through stores the dealer could afford to sell it at 1 or 2 cents per quart less than is now the general custom. Even then, however, the price to the consumer could not be more than 2 cents per quart below the price of milk delivered at his door at present. Is the service that the dealer renders worth 1 or 2 cents per quart of milk delivered? The answer to this question will, to a large degree, answer the question of whether the distribution of milk through stores would reduce the cost. The consumer wants the milk at a definite time each day, and his time is generally so occupied that he cannot afford to go to the corner store to effect a saving of only a few cents. The milk dealer makes a specialty of milk delivery and has built up an organization that renders a very valuable service; it is very doubtful if this service could be eliminated without injury to the consumers and a decreased consumption of milk.

Functions of the Milk Store.—The chief function of the store in handling milk is as an accommodation to customers in case of emergency. Often the housewife finds that she needs an extra quart of milk after the milkman has gone, and the store then provides a very important service. In this way the handling of milk by the store not only serves as an accommodation, but results in an increased consumption of milk, as in many cases the extra quart of milk would not be purchased if it were not for the store.

Another important function of the milk store is to provide refrigeration for the milk. Many poor families cannot afford to have a refrigerator and they depend on the milk store to a large extent for their milk.

In New York city large quantities of milk in bulk are sold by stores which are usually owned by the dealers themselves. The price for this milk is, as a rule, considerably less than for bottled milk and these stores, therefore, permit the people to get their milk at a reduced price. The method of handling milk in "bulk," however, has its disadvantages from a sanitary standpoint unless rigidly controlled; and in many cities it is not permitted.

METHODS OF DELIVERY

Although the automobile truck is used to a considerable extent, especially for wholesale trade, or for very scattered retail trade, the horse and wagon, usually a one-horse outfit, is most commonly used. Each delivery outfit will serve from 150 to 300 retail customers, the driver collecting the empty bottles as he delivers the milk. Bills are usually collected by the driver on certain days of the week. Where night deliveries are made the bills must be collected on the return trip, while in the

case of daylight deliveries, the bills are usually collected at the time the milk is delivered.

FIG. 125.—Horse and wagon for milk delivery.

A study was made of several retail delivery routes; four of the routes were covered by horse-drawn vehicles, two by gasoline truck, and one by electric truck. The following table gives some of the results of this study:

TABLE 104

STATISTICS ON RETAIL DELIVERY ROUTES

	4 Horse-Drawn Vehicles Routes, Average.	2 Gas Car Routes, Average	Electric Truck Route.
Average number of customers	266.5	170	173
Average number customers per stop	2.8	1.3	1.4
Average time vehicle standing	2 hrs. 35 min.	4 hrs. 56 min.	4 hrs. 33 min.
Average time vehicle moving	4 hrs. 33 min.	3 hrs. 18 min.	2 hrs. 49 min.
Per cent of time spent moving	63	40	38
Average number of packages delivered per customer	1.8	1.8	1.8
Average number of packages delivered per stop	5.1	2.3	2.6
Average miles traveled per package delivered	0.04	0.12	

The number of packages per stop, as well as the number of customers served per stop, was the highest for the horse-and-wagon routes, because they were the most compact. The driver would often deliver a carrier full of milk on one side of the street, and return to the wagon and deliver another carrier on the other side of the street at a single stop.

The figures illustrate the value of either electric or gasoline trucks on long and scattered routes. The streets covered by these trucks were very hilly and, at the time of study, very muddy.

FIG. 126.—Auto truck for scattered delivery.

With the four horse-and-wagon routes on the first trip out an average of 115 customers (varying from 85 to 165) were served while the wagon was slowly moving; and 110 customers (80 to 140) were

FIG. 127.—Unloading returned bottles at the city plant.

served while the wagon was standing. With the trucks, all deliveries were made while the machines were standing still. It is also interesting to note, as an advantage of the horse-drawn vehicle for the ordinary retail delivery route, that on each of these routes the horse turned the wagon completely around, without the guidance of the driver, an average of seven times during the covering of the route, while the driver was delivering the milk.

TIME OF DELIVERY

The time of delivery to the consumer varies in different cities and in different sections of the country. In certain sections of the South, two deliveries are often made by the producer-dealers, one in the morning and one in the afternoon. This is not a common practice, however, with the large city milk dealer. In many Pacific Coast cities, milk is delivered in the day time; the delivery wagons usually leave the plant about 7 or 8 A.M., and return in the afternoon. In most eastern cities, the deliveries are made during the early morning hours in the summer time, usually between 1 and 7 A.M.; in the winter, however, the daylight system is common in the East and is the usual practice in northern cities. The principal reasons for the practice of the early morning deliveries are:

1 People have become accustomed to having the milk delivered to them before breakfast.

2. The work is done during the cooler hours.

3. There is less delay at night than in the daytime, as traffic is lighter.

The following advantages have been advanced for daylight delivery (1):

1. Larger sales of milk.
2. Better collection of cash.
3. Better collection of empty bottles.
4. Less theft.
5. Better working conditions for drivers and horses.
6. Greater opportunity for municipal supervision.

SIZE OF LOAD CARRIED

The size of the load carried by one delivery outfit will depend a great deal on the territory covered and the type of trade. Where the customers are scattered, a driver cannot handle as large a load as where the trade is more compact. Where the milk has to be carried upstairs, also, less trade can be handled by one man. Other factors are the amount of collecting that is done, whether the milk is delivered at front or back door, etc.

Table 105 shows the results of an investigation as to the sizes of loads carried in different cities, made by a milk committee to the Federal Food Administration, in 1918. (2)

Table 106 shows the average sizes of loads carried in certain eastern cities, according to an investigation made by the Dairy Division, U. S. Department of Agriculture, in 1914.

From the foregoing tables, it can be seen that there is considerable variation in the size of loads carried on various routes. In some cases, unusually small loads are carried because of the fact that the dealer has

re-routed the district; i.e., he has taken some off the load when it has reached a certain maximum and put on another wagon. In this way he provides for picking up new trade and expanding the business.

TABLE 105

SIZES OF LOAD CARRIED BY MILK WAGONS IN VARIOUS SECTIONS OF THE UNITED STATES (2)

Section.	Number of Quart Points Carried.*
New York city	252
Towns in New York State, outside New York City	250
Chicago, Boston, Baltimore and Washington	385
Philadelphia	299
New England (except Boston)	242
Milwaukee	299
Indiana, Illinois, Iowa, Kentucky, Tennessee, Louisiana and Missouri	268
Ohio	361

* The following are considered as one quart point: One quart, or 2 pints of milk, ½ pint cream 1 quart buttermilk, 1 pound of butter.

TABLE 106

SIZE OF LOADS CARRIED BY ONE DELIVERY OUTFIT IN VARIOUS CITIES

City.	Average Load Carried	
	Number of Wagons Included.	Number of Quarts.
District of Columbia	173	305
Boston	305	296
Pittsburgh	125	294
Baltimore	182	277
Philadelphia	571	277

Effect of Size of Load on Delivery Cost.—Mr. Asa B. Gardiner, a milk dealer in Baltimore, Md., made a cost survey in 1919 of milk delivered in four cities, the results of which are shown in Table 107. (3)

TABLE 107

Cost of Distribution and Size of Load (3)

City.	Average Number of Quarts on Retail Wagons.	City Distribution Costs per Quarts, Cents.
Ottawa, Canada	550	$3\frac{1}{2}$
Philadelphia, Pa	410	$4\frac{1}{2}$
Baltimore, Md	335	$5\frac{1}{2}$
New York, N. Y	240	$7\frac{3}{4}$

According to an investigation by the United States Bureau of Agricultural Economics, the relation of size of load to the cost is as follows:

	Dealer A.	Dealer B.
Wagon load—delivery units *	276	377
Delivery cost per route per year	$2705	$2724
Delivery cost per delivery unit	2.68 cents	1.98 cents

* One pound butter, one bottle of milk, cream, etc., or one quart of buttermilk was considered as one unit.

It is apparent that, up to a certain limit at least, the cost of distributing can be lessened by an increase in load. However, there are many factors upon which the size of load that can be carried will depend. Among these factors are the following:

1. The number of customers a driver can serve, limited by the number of collections to be made, the number of flights of stairs to be climbed, etc.
2. The degree of monopoly which the dealer enjoys (upon which depends the degree of concentration of the business).
3. Amount of store trade in the same territory.
4. Character of the streets; whether hilly, level, paved, etc.
5. Point of delivery, as back door, front door, upstairs, etc.
6. Quantity of milk delivered per customer.

Table 108 shows the seasonal variation in weekly point sales per route in the Chicago and St. Louis markets (8).

TABLE 108

SEASONAL VARIATION IN WEEKLY POINT * SALES PER ROUTE IN CHICAGO AND ST. LOUIS MARKETS † (8)

	Chicago, 1925–1926.		St. Louis, 1923–1925.			
	Retail.		Retail.		Wholesale.	
	Points.	Per Cent.	Points.	Per Cent.	Points.	Per Cent.
January	2092.25	99.79	2398.66	102.68	5245.33	92.24
February	2120.88	101.15	2429.00	103.97	5443.66	95.73
March	2142.00	102.16	2371.00	101.49	5714.33	100.48
April	2144.00	102.25	2396.33	102.58	5642.00	99.21
May	2132.73	101.72	2328.66	99.68	5803.00	102.04
June	2125.05	101.35	2277.33	97.48	6141.33	107.99
July	2042.25	97.40	2184.00	93.49	6101.66	107.30
August	2050.80	97.81	2194.00	93.92	6041.00	106.23
September	2126.25	101.41	2275.00	97.38	5775.00	101.55
October	2083.13	99.35	2363.66	101.18	5646.66	99.30
November	2064.80	98.48	2433.66	104.17	5443.66	95.73
December	2036.50	97.13	2382.33	101.98	5243.00	92.20
Weekly average	2096.72	100.00	2336.14	100.00	5686.72	100.00
Approximate average annual volume on which data are based	186,000,000 pounds		63,000,000 pounds		32,000,000 pounds	

* See Table 109, for allocation of points.

† The sales included all dairy products disposed of to the regular trade.

TABLE 109

ALLOCATION OF RETAIL SALES POINTS IN CHICAGO AND ST. LOUIS DISTRICTS, JANUARY 1, 1928 (8)

	Chicago, Points.	St. Louis, Points.
Certified milk:		
Quarts	1	2
Pints	1	1
Regular and cultured milk:		
Quarts	1	1
Pints	1	$\frac{1}{2}$
Thirds	$\frac{1}{2}$	$\frac{3}{10}$
Half-pints	$\frac{1}{2}$	$\frac{1}{4}$
Cream:		
Quarts	4	4
Pints	2	2
Half-pints	1	1
Quarter-pints	.....	$\frac{1}{2}$
Cocoa drinks:		
Quarts	1	
Pints	1	
Half-pints	$\frac{1}{2}$	
	(Commissions)	
Cottage cheese:		
10- to 16-ounce containers	$.01	1
Butter:		
Pounds	.01	1
Eggs:		
Dozens	.01	

DUPLICATION OF ROUTES

Owing to the large number of milk dealers in all large cities, there is considerable duplication in the delivery of milk. This is illustrated in the following table:

TABLE 110

EXTENT OF DUPLICATION OF DELIVERY ROUTES IN FIVE WISCONSIN CITIES (5)

City.	Total Number of Miles of City Streets.	Total Number Miles Traveled Daily within City in Delivering Milk.	Number of Times Each Mile of Street is Covered.
Milwaukee	602.63	3440.28	5.71
Oshkosh	103.30	377	3.75
Beloit	80	213.54	2.67
Eau Claire	59	142.5	2.42
Madison	81	244	3.01

It has been estimated that the 265 milk wagons distributing milk in Worcester, Mass., cover 2250 miles daily to supply the houses on less than 220 miles of streets. (4)

In the District of Columbia 98 routes were measured in 1914. The average distance traveled for the 98 routes was 19.1 miles, varying from 10.4 miles to 30 miles. Assuming that each of the 250 retail milk wagons in the district at that time covered 19.1 miles, they all traveled 4775 miles or 9.3 times the total mileage of streets in the District of Columbia at that time.

TABLE 111

DISTANCE TRAVELED AND NUMBER OF QUARTS DELIVERED BY MILK WAGONS IN FOUR CITIES

City.	Number of Wagons Included.	Number of Dealers.	Average Miles Traveled.	Average Load, in Quarts, per Wagon.	Average Number Quarts Delivered per Mile Traveled.
Pittsburgh	41	1	14.20	327.10	23.07
District of Columbia	63	14	18.60	301.8	16.20
Baltimore	11	1	20.20	215.0	16.15
Boston	22	1	20.35	245.0	12.03

DELIVERY OF MILK IN PINT BOTTLES

The proportion of milk handled in point bottles is not so high as it formerly was. In Table 112 is shown a comparison of the relative amounts handled in pints in 1914 and in 1922–23.

TABLE 112

A Comparison of the Proportion of Pints to Quarts of Milk Sold in 1914 with 1922–1923

City.	1914			
	Number of Dealers.	Number of Quarts.	Number of Pints.	Proportion of Pints to Quarts.
Boston	27	99,844	64,830	0.65
Washington	13	33,356	35,600	1.06
Pittsburgh	9	26,917	37,040	1.37
Philadelphia	15	80,922	173,300	2.14
Baltimore	10	18,713	50,738	2.71
Total	74	259,752	361,508	1.39
	1922–1923			
New York	11	267,454	29,340	0.11
Baltimore	6	105,129	53,336	0.51
Washington	4	33,300	36,600	1.10
Philadelphia	10	289,360	121,305	0.42
Boston	6	114,468	19,920	0.17
Chicago	10	161,340	68,670	0.42
Pittsburgh	2	83,472	33,582	0.40
Ohio cities: Cleveland, Toledo and Akron	8	114,715	39,028	0.34
Total	57	1,169,238	401,781	0.34

From the table above it is seen that in 1914, 74 dealers in five cities handled on an average 1.39 pints for each quart and that 41 per cent of the bottled milk was handled in pints. The figures for 1922–23 how that 57 dealers in ten cities handled .34 of a pint for each

quart and that only 14.5 per cent of the bottled milk was handled in pints.

Owing to the fact that it costs more to handle the same quantity of milk in pints, milk dealers have in various ways discouraged the use of pint bottles. Perhaps the factor of greatest importance in lessening the amount of milk handled in pints for the past few years has been the price. In 1914 in most cities milk in pints sold for half the price of quarts, whereas at the present time the pint price is usually 1 or 2 cents more than half the quart price. Dealers make this difference in price not only to offset the increased cost of handling milk in pints, but to increase consumption, as many pint customers will buy a quart rather than pay the extra charge for milk in pint bottles.

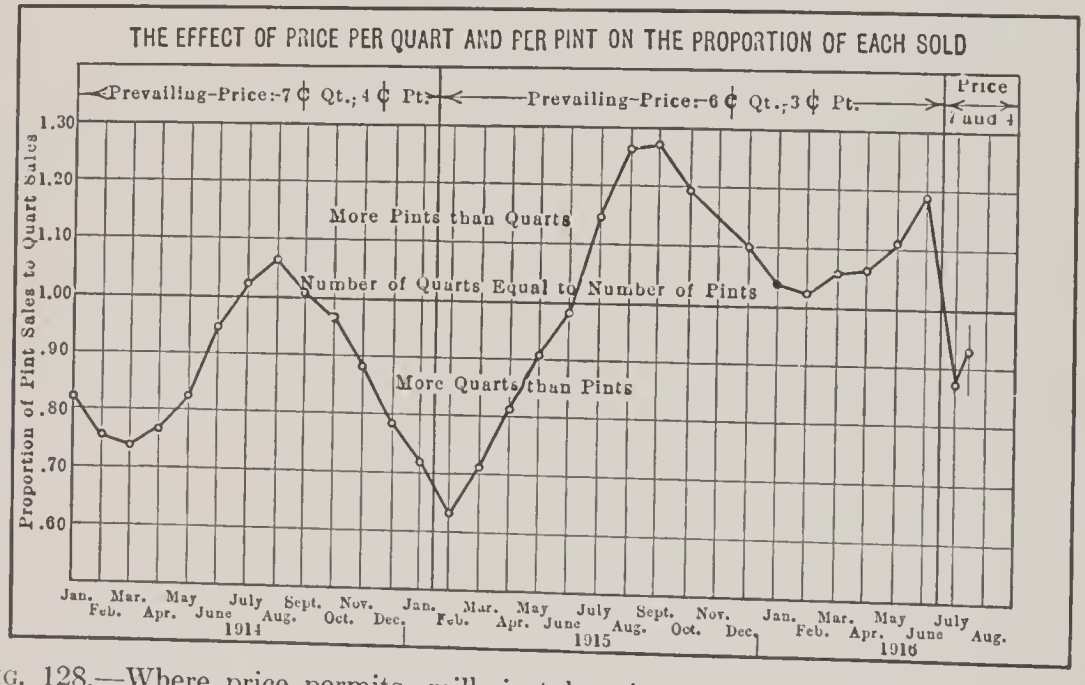

THE EFFECT OF PRICE PER QUART AND PER PINT ON THE PROPORTION OF EACH SOLD
Prevailing Price:-7¢ Qt., 4¢ Pt.
Prevailing Price:-6¢ Qt., 3¢ Pt.
Price 7 and 4
Proportion of Pint Sales to Quart Sales
1.30
1.20
1.10
1.00
.90
.80
.70
.60
More Pints than Quarts
Number of Quarts Equal to Number of Pints
More Quarts than Pints
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. 1914
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. 1915
Jan. Feb. Mar. Apr. May June July Aug. 1916

FIG. 128.—Where price permits, milk is taken in small quantities. At the same proportional price, more pints than quarts of milk will be sold. The cost of distribution is much higher proportionately for pints than quarts. (5)

In the retail trade it takes as long to deliver a pint as a quart, which makes delivery in the smaller package twice as expensive for the same quantity of milk. In wholesale trade the cost of delivering pints, as compared with quarts, is not so much greater as it is in retail trade; hence the differential in favor of quarts is made smaller, if made at all. As a result there is more demand for pints, and distributors who have a large proportion of their trade wholesale still bottle a good deal of milk in pints.

Besides the extra cost of handling the milk in pint bottles, there is

the extra expense of replacing lost bottles. The life of a pint bottle is generally reported as somewhat shorter than that of a quart bottle. This is no doubt owing to the fact that a large number of pints are handled by stores. There is also more temptation for customers to appropriate a pint bottle for household uses, on account of its convenient size. Although in most places this is contrary to law, yet it is done without any feeling of guilt on the part of the housewife.

It is necessary to use small bottles for some kinds of trade, as, for instance, in supplying hotels and restaurants, where the guests are served milk in the bottle; but the cost of delivery and the loss of bottles in connection with this trade are usually small.

In the poorer sections of the city, customers often feel unable to buy more than a pint of milk at a time; this has a tendency to cut down the consumption of milk. If the customer buys the same amount, and two pints sell for more than a quart, as is often the case, then buying by the pint is the more expensive method for the consumer, as he pays for the extra cost of delivery. If there is no difference in the price, then the extra cost of delivery comes out of the profit of the dealer.

In cities where the price for pints has been raised from one-half the price for quarts to more than half, there has been a considerable reduction in the relative number of pints sold. This is illustrated for the city of Milwaukee in 1916 by Hibbard and Erdman in Wisconsin Bulletin No. 285 (see Fig. 128). (5)

DEMANDS OF CONSUMERS

In order to supply the wants of consumers, the milk dealer must put his goods out in various-sized containers. Table 113 shows the variety of the demands on ten selected retail milk routes in Detroit, Michigan, in 1915. (6). The table also shows that there were considerably more pints sold than quarts: the price of pints was then one-half the price for quarts. Table 114 shows the percentages of various products in various sized containers sold in Chicago, St. Louis, and Peoria (8).

MILK-BOTTLE LOSSES

The loss of milk bottles, either through carelessness, theft, or breakage, is an important item. Table 115 is a summary of the replies received from fifty dealers in various cities in answer to a questionnaire sent out from the Dairy Division, U. S. Department of Agriculture.

TABLE 113

VARYING DEMANDS OF RETAIL CUSTOMERS FOR MILK, CREAM AND OTHER MILK PRODUCTS BY DIFFERENT RETAIL ROUTES (6)

Number of Customers	Common Milk.				Certified and Special.				Cream.						Buttermilk.		Average Daily Sales.		Total Bills Receivable.	Average Credit per Customer.
	Number of Quarts.	Percentage of Customers.	Number of Pints.	Percentage of Customers.	Number of Quarts.	Percentage of Customers.	Number of Pints.	Percentage of Customers.	Number of Pints.	Percentage of Customers.	Number of ½ Pints.	Percentage of Customers.	Number of ¼ Pints.	Percentage of Customers.	Number of Quarts.	Percentage of Customers.	Per Route.	Per Customer.		
351	122	34.7	236	67.2	3	0.8	4	1.1	3	0.8	34	9.6	24	6.8	4	1.1	$24.44	$0.069	$247.00	$0.703
214	92	42.9	130	60.7	5	2.3	....	....	....	....	7	3.2	12	5.6	2	.9	14.50	.067	183.00	.855
343	156	45.4	215	62.6	4	1.1	5	1.4	4	1.1	43	12.5	25	7.2	8	2.3	27.70	.080	409.00	1.192
273	109	39.9	188	68.8	3	1.0	4	1.4	5	1.8	30	10.9	35	12.8	10	3.6	22.22	.081	261.00	.956
319	130	40.7	207	64.8	8	2.5	2	.6	....	....	28	8.7	28	8.7	10	3.1	24.02	.075	339.00	1.062
356	129	36.2	239	67.1	....	....	....	....	....	....	51	14.3	57	16.0	6	1.6	26.54	.074	351.00	.985
336	134	39.8	252	75.0	1	.2	....	....	....	....	12	3.5	1	.2	13	3.8	22.61	.067	234.00	.696
344	183	53.1	251	72.9	1	.2	4	1.1	....	....	8	2.3	4	1.1	10	2.9	26.54	.077	321.00	.933
342	157	45.9	250	73.0	10	2.9	2	.5	2	.5	33	9.6	25	7.3	6	1.7	28.62	.083	440.00	1.286
125	70	56.0	70	56.0	2	1.6	2	1.6	3	2.4	20	16.0	12	9.6	7	5.6	11.83	.093	176.00	1.408
Average 300..	128	42.6	204	68.0	3.7	1.2	2.3	.7	1.7	.5	26.6	8.8	22.3	7.4	7.6	2.5	$22.90	$0.076	$296.00	$0.986

TABLE 114

SUMMARY OF FIFTY REPLIES TO QUESTIONNAIRE ON MILK BOTTLE LOSSES

Size of Plant. Bottles Filled Daily.	Number of Dealers.	Bottles Filled Daily Average per Month.	Bottles Bought per Month. Average per Dealer.	Average Number of Bottles Bought Each Month. for Every 100 Bottles Filled Daily.	Cost of Bottles per Month. Average per Dealer.	Average Cost per Every 100 Bottles Filled Daily.	Bottles Lost and Broken. Dealers' Estimate* per Dealer.	Average Number of Bottles Lost and Broken Daily per 100 Bottles Filled.	Proportion of Broken to Lost Bottles. Dealers' Estimates.	Trips per Bottle. Dealers' Estimates.*
Up to 1,000	5	740	523	70.6	$27.60	$3.75 (0.57– 9.03)	34	4.6 (1.4–13.3)	1 : .8	21
1,001 to 2,000	7	1,685	1,114	66.1	51.47	$3.05 (1.50– 3.60)	43	2.6 (1.2– 4.5)	1 : 1.7	13
2,001 to 5,000	5	3,800	5,756	151.5	238.00	$6.26 (2.80–10.00)	190	5.0 (1.0– 9.4)	1 : 2.5	14
5,001 to 10,000	16	7,906	9,446	119.5	326.50	$4.13 (2.50–10)	300	3.8 (1.5– 8.3)	1 : 5.3	15
10,001 to 50,000	13	23,332	20,135	86.3	1079.40	$4.63 (1.76–13)	980	1.2 (1.8–10.0)	1 : 8.8	17
Over 50,000	4	67,500	90,050	133.4	3071.00	$4.55 (3.33– 6.50)	2950	4.3 (3.5– 5.6)	1 : 13.0	19
	50	14,686	17,649	120.2	$624.59	$4.52 (0.57–13.00)	632.34	4.3 (1.0–13.3)		

* Estimates were not received from all the dealers.

TABLE 115

RETAIL AND WHOLESALE DISTRIBUTION OF REGULAR AND CULTURED MILK IN CHICAGO, ST. LOUIS, AND PEORIA MARKETS (8)

	Chicago, 1925–1926		St. Louis, 1925		Peoria, 1926–1927	
	Retail. Per cent.	Wholesale. Per cent.	Retail. Per cent.	Wholesale. Per cent.	Retail. Per cent.	Wholesale. Per cent.
Regular milk, sold in:						
Gallons	.....	32.36	.....	6.73	.....	16.48
Quarts	84.65	45.25	85.90	67.10	85.13	58.99
Thirds	.....	.24	.003	.61	.09	2.09
Pints	15.06	13.53	14.06	22.17	14.44	13.06
Half-pints	.29	8.62	.04	3.39	.34	9.38
	100.00	100.00	100.00	100.00	100.00	100.00
Ratio of quart to pint sales	5.62:1	3.34:1	6.11:1	3.03:1	5.90:1	4.52:1
Volume (pounds) on which percentages are based	643,285,814	125,435,326	45,072,015	24,152,937	5,494,923	144,815
Cultured milk, sold in:						
Gallons	.....	5.87	.....	1.81		
Quarts	98.65	89.05	85.75	94.33	89.68	
Thirds	.27	.37	.....	.40		
Pints	1.08	1.14	13.73	2.17	10.32	
Half-pints	.....	3.57	.52	1.29		
	100.00	100.00	100.00	100.00	100.00	
Volume (pounds) on which percentages are based	14,112,172	4,693,919	1,111,690	2,366,391	22,714	

The results of a recent survey on the life of the milk bottle, made from the reports of 76 milk dealers, is as follows: The arithmetic average life of the bottle for the 76 dealers was 37.32 trips, with a range varying from 6 to 91 trips. The " median " was 32 trips, and the " mode " or most common figures given by the 76 dealers ranged between 20 and 30 trips. From these data it can be conservatively estimated that the average milk bottle has a life of only about 30 trips.

Among the suggestions that have been made for solving the milk-bottle loss problem, are the following:

1. Charge for all bottles delivered.
2. Use of single-service containers.
3. Commissions to drivers for bottles returned.
4. Establishment of milk-bottle exchanges.
5. Use of a special bottle for the wholesale trade and a charge made for the bottle.
6. Universal interchangeable bottle.
7. Laws prohibiting junk dealers from handling milk bottles.
8. Severe penalties for using milk bottle for anything but milk.

Single-service Containers.—Several single-service containers for milk, most of them made of paper fiber, have been devised during recent years. In some cases the containers are shipped from the factory to the plant, while in other cases the plant purchases or rents a machine for making the bottles.

Single-service containers for milk have not come into general use as yet. Some of the advantages of the fiber bottle are the following:

1. There are no bottles to collect.
2. There is no washing of bottles.
3. Less space is required, both in shipping and on the delivery trucks.
4. Less refrigerating space is required.
5. Extensive advertising can be carried on with their use.
6. They make good containers for buttermilk, especially when handled by stores. They are very convenient for the store to handle.

The following are some of the disadvantages of the fiber bottle:

1. It is more costly.
2. The cream line is not visible.
3. It is less convenient to handle in the plant.
4. The labor cost of filling is somewhat greater than in the case of glass bottles.
5. The consumer cannot easily detect the presence of sediment.

Paper or fiber milk bottles are not used to any extent for retail family trade, although they are being tried out in several places at the present time. The item of cost seems to be the principal reason why they have not as yet been used more extensively. For store trade or for factory or office trade, where the milk is consumed soon after deliv-

ery, they seem well adapted. There has recently been considerable progress made in the development of machinery for the manufacture of these containers, and accurate data are being collected as to the cost in comparison with the cost of delivery in glass bottles. If the paper container can be manufactured and handled at as low a cost as that for the glass bottle (taking into consideration the life of the glass bottle, cost of washing, etc.), considerable development along this line may be expected in the future.

SYSTEMS OF PAYING MILK-WAGON DRIVERS

The following methods of paying route salesmen have been found to be in use:

1. Straight salary, which is usually increased according to the length of service with the company.
2. Salary and commission.
3. Commission.

Many factors are used as the bases for various commission systems. Among these are the following:

Load carried.
Increase in daily sales.
New customers obtained.
Collections.
Return of bottles.
Amount of cash turned in.
Cleanliness of man and of delivery outfit.
Promptness and politeness.
Minimum of returned goods.

The system of paying commissions has many advantages over a flat salary, since the driver shares in the prosperity of the company and thus has an incentive for increasing his efficiency and taking more interest in his work.

NUMBER OF MEN REQUIRED FOR MILK DELIVERY

In Table 116 is shown the number of drivers, route foremen, and office clerks employed at plants of various sizes. The number of men in the administrative force is also shown.

From the average number of routes per 100 gallons, the approximate average load carried by the dealers with businesses of various sizes can be determined. It will be noted that the larger dealers have fewer routes, per 100 gallons handled, than the smaller ones. This is in part due to the fact that in many cases they handle a greater proportion of bulk milk.

TABLE 116

NUMBER OF ROUTE FOREMEN, OFFICE CLERKS AND ADMINISTRATIVE OFFICERS EMPLOYED AT MILK PLANTS OF VARIOUS SIZES (7)

	Up to 100 Gallons.	101 to 250 Gallons.	251 to 500 Gallons.	501 to 1000 Gallons.	1001 to 1500 Gallons.	1501 to 2000 Gallons.	2001 to 3000 Gallons.	3001 to 5000 Gallons.	5001 to 10,000 Gallons.	Over 10,000 Gallons.	Total
Number of plants	4	18	31	35	15	11	12	16	7	4	153
Total gallons handled daily	340	3,035	12,075	27,605	19,550	19,200	31,450	62,750	51,500	69,000	296,505
Average gallons per plant	85	168	390	788	1,303	1,745	2,621	3,921	7,357	17,250	1,938
Total number of routes	4	44	137	343	186	225	305	606	434	553	2,037
Average number routes per plant	1.0	2.4	4.4	9.8	12.4	20.5	25.4	37.9	62.0	138.2	
Variation	.....	1–3	3–15	3–20	6–24	14–29	13–41	14–58	36–105	100–195	1–195
Average number of routes per 100 gallons handled daily	1.2	1.4	1.1	1.2	.9	1.2	.97	.96	.84	.80	.95
Route Foremen.											
Total number route foremen	.....	.....	.....	50	31	32	38	85	59	57	352
Average number route foremen per plant	.....	.....	.....	1.4	2.0	3.0	3.2	5.3	8.4	14.2	
Average number route foremen per 100 gallons	.....	.....	.....	.18	.16	.16	.12	.13	.11		
Average number routes per route foremen	.....	.....	.....	6.7	6.0	7.0	8.0	7.1	7.4	9.7	
Administrative Force.											
Total	.....	9.41	23.08	39	15	15	16	31	15	12	175.49
Average per plant	.....	.52	.74	1.1	1.0	1.4	1.3	1.9	2.1	3.0	1.1
Average per 100 gallons handled daily	.....	.31	.19	.14	.08	.07	.05	.05	.03	.02	.06
Office Force.											
Total number of clerks	.....	9.41	24.08	93	36	52	57	123	99	177	
Average per plant	.....	.52	.77	2.7	2.4	4.7	5.6	7.7	14.1	44.2	
Average number per 100 gallons handled daily	.....	.31	.20	.34	.18	.27	.21	.20	.19	.25	.23
Average number routes per office clerk	.....	4.7	5.7	3.7	5.2	4.3	4.5	4.9	4.4	3.1	

The average number of routes per route foreman varies, but as a general rule the larger dealers are able to economize in this respect, and fewer route foremen are required, per 100 gallons handled and per route, than with the smaller dealers. This same situation also exists in the case of administrative officers. The administrative officers of the smaller plants, however, generally exercise a closer personal supervision of the work than is the case with the large plants, and for this reason in many cases fewer men are required for the actual operating.

The number of office clerks required, in relation to the number of routes, depends more on the system of accounting used than on the size of the business. Some of the large dealers have many more office clerks, per route operated than some of the smaller ones.

Table 117 presents some interesting information as to the number of men employed in plants in different cities. Figures from the principal plants in each city were obtained.

TABLE 117

Principal Plants in—	Average Number of Routes per Route Foreman.	Average Number of Routes per Office Clerk.	Average Number of Routes per Stable-man.	Average Number Gallons Handled per Milk Handler †	Average Number of Routes per Milk Handler.†
Buffalo	7	6.5	7	125	1.8
Milwaukee	12.2	6.3	6.3	212	2.1
Minneapolis and St. Paul	9.5	7.9	.....	204	2.0
Cleveland and Akron	4.5 *	4.5	7.5	167	1.5
Baltimore	7.5	6.4	5.0	186	2.3
Washington	.....	3.0	7.3	171	1.7
Philadelphia	7.0	7.0	9.7	216	1.7
Boston	6.3	4.3	4.6	288	1.5
Pittsburgh	6.1	3.9	5.1	317	2.1
Detroit	10.2	6.4	10.1	271	2.0
Seattle	9.3	4.7	8.6	200	1.8
Spokane and Butte	10.0	2.5	10.0	123	1.4
Portland	4.1 *	6.8	.....	140	2.1
Los Angeles and San Francisco	7.6	5.9	.....	277	2.0

* Includes collectors and solicitors.

† Under this heading all men in the plant, including engineers and firemen, whose work deals with the milk department, are included.

CHECKING THE ROUTE SALESMEN

The route driver generally makes out his order for goods a day ahead, so that the proper quantity can be bottled at the plant. This quantity is given to him and charged to him before he leaves the plant for his route, and he is credited for all that he brings back when he returns. He is charged for the difference. The following forms are similar to those used at milk plants for checking the driver out and in and for making his daily reports.

Daily Orders _____ 192____ Checked by Out / In Route No._____

	Milk			Buttermilk		Skimmilk		Cream			½	But.	Cheese
	cans	qts.	pts.	cans	qts.	cans	qts.	cans	qts.	pts.	pts.	Lbs.	Packages
Drivers' Orders													
Extras													
Total Out													
Total Returned													
Net Sales													

FIG. 129.—Form for checking wagon driver out and in.

RECEPTACLE REPORT

		cans	Bottles		
			Qts.	Pts.	½ pts.
Out					
Returned	Empty				
	full				
	total				
Over					
Short					

FIG. 130.—Form for checking receptacles taken out and returned. Used in connection with the form shown in Fig. 129.

DRIVER'S DAILY REPORT

Driver_____ No._____ Date_____

	Out	In	Net	Price	Value
Gallons bulk milk					$
Quarts milk					
Pints milk					
Quarts buttermilk					
Gallons bulk cream					
Quarts cream					
Pints cream					
Half pints cream					
Gallons skim milk					
Pounds butter					
Value of load					

Currency	$
Gold	
Silver	
Pennies	
Checks	
Checks	
Checks	
Checks	
Total cash	

CASH ACCOUNT

Wholesale sales (cash) (see other side)	$
Cash for tickets (see ticket acct.)	
Cash on account (see other side)	
Cash sales	
Total cash	

Wholesale sales (cash)	$
Charge sales (as per route book)	
Loose tickets turned in	
Cash sales	
Total sales	

TICKET ACCOUNT

Tickets charged to driver:		
Books No.____ to No.____	$	
Books No.____ to No.____		
Total		

Charged on account	$	
Sold for cash		
Balance charged to driver		
Total		

CONTINUOUS CONTAINER ACCOUNT

	10-gallon cans	5-gallon cans	1-gallon cans	Quarts	Pints	Half pints				
Out										
Taken out to-day										
Total out										
Returned to-day: Empty										
Returned to-day: Full										
Total returned										
Still out										

(Over)

FIG. 131.—Form for balancing each individual driver daily, where the cash or "ticket" system is used principally.

COLLECTED ON ACCOUNT

Name	Address	Page No.		Cash
				$
			Total	

WHOLESALE SALES (CASH)

Name	Address	Page No.	Quantity goods	Amount
				$
			Total	

TICKETS SOLD TO-DAY

Name	Address	Page No.	Coupon Nos.	Charge	Cash
				$	$
			Total		

Report audited by _____

FIG. 132.—Reverse side of form shown in Fig. 131.

No. ..... Date.....193 .....

M.....

Route No. ..... Address..... .....

To Tickets $1.00 Cr:.....

No..... Date.....193...

M.....

To YOUR NAME HERE, Dr.

To Tickets Rec'd Paym't.....Date..... ....19..

See that this Bill is Receipted. Please retain this Bill. Report any dissatisfaction at once.

One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint	One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint
One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint	One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint
One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint	One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint
One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint	One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint
One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint	One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint
One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint	One Pint — Good For **ONE QUART MILK** YOUR NAME HERE — One Pint

FIG. 133.—Tickets used with the "cash" system. The customer leaves in the bottle tickets for the number of quarts or pints of milk desired.

ROUTE BOOK

Page No..... Account No.....

Name..... .....Milk daily.

Address..... .....Cream daily.

Month

Date	Milk			Cream				Butter-milk, Quarts	Skim, Quarts	Butter, Pounds	Cheese, Packages	Tickets	Credit
	Gallons	Quarts	Pints	Gallons	Quarts	Pints	Half Pints						
1													$
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
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21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														

Balance forward. $.....

.....Quarts milk at $..... $.....

.....Pints milk at $..... $.....

.....Half pints cream at $..... $.....

..... $..... $.....

Total..... $.....

Date paid..... $.....

Balance forward..... $.....

FIG. 134.—The route book is used with the credit system. One page is used for each customer.

CREDIT VERSUS CASH SYSTEM OF COLLECTION

There are, in general, two methods of handling the accounts in the retail milk business.

1. **The Credit System.**—With this system a route book[1] is used, with one customer's name on each page. The driver keeps the book scored according to the quantity of goods delivered each day, and bills are made out from this book, either monthly or weekly. In order to balance the driver, where this system is used, it is necessary either to keep his account open for a month and hold him responsible for all shortages at the end of the month, or to go over his route book each day and balance him daily. This, of course, requires considerable clerical work.

FIG. 135.—Auto truck for wholesale delivery.

2. **The Ticket System.**—With this system the driver sells tickets,[2] good for so much milk, to customers for cash in advance, and he collects a ticket for each quart of milk delivered. With this system it is comparatively simple to balance the driver daily, as he must turn in each day cash or tickets for the amount of the goods and tickets charged to him.

Some of the advantages of the ticket system are:

1. No bad bills.
2. Money collected in advance.
3. Less time required for making collections.
4. Less bookkeeping required.
5. Less loss of bottles, as the customer is supposed to put the ticket in the bottle each day.

The success of the ticket system depends on the cooperation of all the dealers in a particular locality.

[1] See Fig. 134.

[2] See Fig. 133.

REFERENCES

(1) Report of the Mayor's Committee on Milk, City of New York, December, 1917.
(2) The Production, Distribution and Food Value of Milk: A Report to Herbert C. Hoover, U. S. Food Administrator, 1918.
(3) The Milk Dealer, Vol. 10, No. 2.
(4) Municipal Reference Bulletin, No. 8, Committee of Health, Chicago City Council, page 11.
(5) Hibbard, B. H., and Erdman, H. E., Marketing Wisconsin Milk. Bul. 285, Wis. Agri. Exp. Sta., Madison, Wis., 1917.
(6) Clement, C. E. and Warber, G. P., The Market Milk Business of Detroit, Mich., in 1915. U. S. Dept. Agri. Bul. 639, 1918.
(7) Clement, C. E., Milk Plant Operation. U. S. Dept. Agri. Bul. 973, 1923.
Parker, H. N., City Milk Supply, 1917.
King, Clyde L., The Price of Milk, 1920.
Investigation and Analysis of the Production, Transportation, Inspection and Distribution of Milk and Cream in New England, Boston Chamber of Commerce, July, 1915.
Report of the 13th Annual Convention of the International Milk Dealers' Association, Oct. 8, 9, 1920.
Erdman, H. E., The Marketing of Whole Milk, The Macmillan Company, New York, 1921.
Milk Plant Letters, U. S. Dept. Agri.
(8) Brown, C. A., Costs and Margins and other Related Factors in the Distribution of Fluid Milk in Four Illinois Market Areas. Ill. Agri. Exp. Sta. Bul. 318, 1928.
Ross, H. A., The Demand Side of the New York Milk Market. Cornell Agri. Exp. Sta. Bul. 459, 1927.
Ross, H. A., Some Factors Affecting the Demand for Milk and Cream in the Metropolitan Area of New York. U. S. Dept. Agri. Tech. Bul. 73, 1928.
Ross, H. A., The Marketing of Milk in the Chicago Dairy District. Ill. Agri. Exp. Sta. Bul. 269, 1925.
Horner, J. T., The Detroit Milk Market. Mich. Agri. Exp. Sta. Bul. 170, 1928.

CHAPTER XXIV

COST OF MILK DISTRIBUTION

No treatment of market milk problems is complete without a discussion of milk prices and of the cost of milk distribution. The costs of milk distribution begin at the farmer's door, and include hauling to the station, transportation to the city and to the dealer's plant, the various processes through which the milk goes at the plant, and delivery to the consumer's door.

DEALER'S SPREAD

The difference between the price paid by the consumer and the price paid to the producer is called the dealer's "spread." In this spread is included the dealer's profit, as well as his expenses or costs of distribution. There is considerable variation in the spreads taken by dealers in various cities, and by different dealers in the same city. Table 118, showing the spreads taken by dealers in different cities for milk delivered to various classes of trade, is quoted from Hoard's *Dairyman.*

Dr. Chas. E. North (4) in his report of the Milk Survey of Kansas City, Missouri, published July, 1921, quotes from the Statistical Bulletin of the International Milk Dealers' Association for June, 1921, as follows, regarding dealers' spreads in the cities named:

City Market.	Dealer's Spread.
Calgary	$0.064
Denver	.044
Washington	.065
Chicago	.096
Winnipeg	.075
Baltimore	.061
Detroit	.091
Minneapolis	.056
Kansas City, Mo	.091
St. Louis	.101
Ottawa	.054
Seattle	.076
Milwaukee	.054
Omaha	.101

Table 119 shows the dealers' spreads in the Chicago market for a period of years. (8)

TABLE 118

DEALERS' MARGINS (SPREAD BETWEEN PRICE PAID AND SELLING PRICE) ON QUART SALES OF STANDARD GRADE MILK DELIVERED TO DIFFERENT CLASSES OF TRADE (1)

	Bulk Milk to Hotels. (Cents.)	Bottled Milk to Hotels. (Cents.)	Bottled Milk to Families. (Cents.)
New York	2.95	5.95	6.87
Chicago	2.89	4.85	5.64
Philadelphia	2.65	3.95	4.76
Boston	3.96	4.65	6.63
Baltimore	4.90	6.15	6.76
Pittsburgh	3.46	5.36	5.63
Cleveland	2.37	3.97	6.19
Detroit	3.28	5.77	7.02
Milwaukee	1.74	3.62	4.24
Minneapolis	2.47	3.52	4.84
New Orleans	1.67	4.42	6.42
San Francisco	2.18	4.57	6.05
Averages of above cities	2.876	4.731	5.92

The figures given are based on prevailing milk prices for the nine months ending with March, 1919. The average margin or gross profits received by dealers in the twelve cities was 2.876 cents per quart when delivered in bulk to hotels or restaurants; 4.731 cents per quart when delivered in bottles to restaurants and retail stores; and 5.92 cents per quart when delivered in bottles to the family trade.—U. S. Bureau of Markets.

EXTRACTS FROM AVAILABLE DATA ON COST OF MILK DISTRIBUTION

During recent years there have been many investigations of the milk business and of the cost of milk distribution. There is naturally a great variation in the costs of distribution. Owing to the fact that there is no standard uniform system of cost accounting in the milk business, there is also a great variation in the allocation to different items of costs by various investigations and by various dealers. In order to give a general idea of the cost of milk distribution and of the various items of cost, as well as the variations in total cost, a summary of some of the available data on the subject is presented on the following pages.

Table 120 gives an analysis of the costs and prices paid and received by milk dealers in the districts named, for the six months' period ending June 30, 1917.

These figures were obtained from the "Report to Herbert C. Hoover, U. S. Food Administrator, by the Milk Committee, Clyde L. King, Chairman." This Committee was appointed by the Food Administra-

TABLE 119

DEALERS' MARGINS IN CHICAGO DAIRY DISTRICT, 1908–1927 (8)

(Figures indicate cents per quart and are the difference between price paid producers at country stations and retail price per quart)

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Average
1908	4.7	3.7	3.7	4.1	4.7	5.0	4 7	4.3	4.1	3.9	3.7	3.7	4.2
1909	3.7	3.7	3.9	4.0	4.6	5.0	4.7	4.3	4.1	3.7	4.3	4.2	4.2
1910	4.2	4.3	4.7	4.9	5.4	5.7	5.4	5.2	5.0	4.3	3.9	3.7	4.7
1911	3.7	3.9	4.3	5.2	5.6	5.9	5.2	4.9	4.9	4.3	4.0	3.9	4.7
1912	4.0	4.1	4.5	5.2	5.7	5.9	5.2	4.9	4.8	4.6	4.2	4.1	4.8
1913	4.2	4.3	4.6	4.8	5.3	5.5	5.1	4.8	4.7	4.2	4.0	3.9	4.6
1914	3.9	4.2	4.5	4.8	5.3	5.6	5.1	4.7	4.7	4.1	3.9	3.9	4.6
1915	4.0	4.2	4.5	4.9	5.4	5.6	5.2	4.7	4.7	4.1	3.9	3.9	4.6
1916	4.0	4.2	4.5	4.5	4.9	5.3	4.7	5.3	5.3	4.9	4.5	4.5	4.7
1917	4.6	4.7	5.0	4.8	5.7	6.6	5.4	5.1	5.1	5.6	5.1	5.1	5.2
1918	5.1	5.4	5.8	6.3	7.6	8.1	7.1	6.6	6.7	5.9	6.1	5.9	6.4
1919	5.9	6.5	6.6	7.0	8.6	8.6	7.6	7.4	7.4	7.2	7.3	7.2	7.3
1920	7.3	7.8	7.8	8.1	8.2	8.1	8.1	8.0	8.0	8.0	8.4	8.4	8.0
1921	8.6	8.9	8.9	8.9	9.6	9.6	9.1	9.1	8.8	8.2	8.1	8.1	8.8
1922	8.1	8.3	8.3	8.3	8.3	8.6	7.7	7.6	7.7	7.6	7.6	7.5	8.0
1923	7.6	7.6	7.8	7.8	8.1	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.0
1924	8.2	8.2	8.2	8.6	9.1	9.1	8.6	8.4	8.4	8.8	8.8	8.8	8.6
1925	8.8	8.8	8.8	8.8	8.9	8.9	8.6	8.5	8.5	8.5	8.5	8.6	8.7
1926	8.6	8.6	8.6	8.1	8.6	8.8	8.6	8.4	8.4	8.5	8.6	8.6	8.5
1927	8.6	8.6	8.6	8.6	8.8	8.8	8.5	8.6	8.6	8.6	8.6	8.6	8.6

TABLE 120

THE AVERAGE SELLING PRICE, AVERAGE SPREAD, AVERAGE PRICE PAID PRODUCER AND AVERAGE EXPENSES PER QUART, FOR CERTAIN MILK DEALERS, ON ALL MILK HANDLED; ALSO RATIO OF NET EARNINGS TO NET SALES, FOR SIX MONTHS ENDING JUNE 30, 1917 (2)

District.	A.	B.	C.	D.	E.	F.	G.	H.	J.
Average price received by dealer	$0.09646	$0.08222	$0.07651	$0.06354	$0.08258	$0.08192	$0.05957	$0.08714	$0.04784
"Spread" taken by dealer	.04580	.02829	.03081	.02331	.03699	.02537	.01601	.03537	.01629
Average price paid producer	.05066	.05393	.04570	.04023	.04559	.05655	.04356	.05177	.03155
Country expenses and freight	.00806	.00282	.00239	.00772	.00789	.00553	.....	.00313	
Factory expenses (includes cartage, railroad station to plant)	.01024	.00697	.00646	.00397	.00801	.00654	.00369	.00732	.00626
Delivery expenses	.02063	.01006	.01247	.00743	.01517	.00805	.00725	01238	.00701
Selling, administration and general expenses (includes advertising, insurance, taxes, etc.)	.00467	.00491	.00600	.00234	.00360	.00369	.00340	.00934	.00177
Total cost and expenses (includes cost of milk)	.09426	.07869	.07103	.06169	.08026	.08036	.05790	.08394	.04659
Net earnings	.00220	.00353	.00548	.00185	.00232	.00156	.00167	.00320	.00125
Ratio of net earnings to net sales	2.28%	4.30%	7.17%	2.91%	2.82%	1.90%	2.80%	3.67%	2.62%

District A.—New York city (Metropolitan District).
" B.—New York State (except New York city).
" C.—Chicago, Boston, Baltimore and Washington.
" D.—Pittsburgh.
" E.—Philadelphia.
District F.—New England (except Boston).
" G.—Milwaukee.
" H.—Indiana, Illinois (except Chicago), Iowa, Kentucky, Tennessee, Louisiana and Missouri.
" J.—Ohio.

tion during the war, to consider the production and distribution of milk for city markets. (2)

Table 121 gives a summary of data collected by the Mayor's Committee on milk from five of the large distributing companies in New York City, for ten months ending November 1, 1917. (3)

TABLE 121

COST OF MILK DISTRIBUTION FOR FIVE LARGE DISTRIBUTING COMPANIES IN NEW YORK CITY FOR TEN MONTHS ENDING NOV. 1, 1917 (3)

Cost of Items.	Dealer A.	Dealer B.	Dealer C.	Dealer D.	Dealer E.
Average selling price, quart	0.08680	0.08322	0.08855	0.11628	0.093144
Amount paid to producers	.05627	.05198	.05645	.05782	.045685
Country station expenses	.00269	.....	.00911	.00408	.014711
Freight	.00563	.....	.00704	.00986	.007984
City station expenses	.01107	.04138	.....	.00921	.023738
Delivery	.00857	.....	.....	.02820	
Cartage, ferriage	.....	.01683	.01358		
Factory expense					
Administration, clerical and overhead	.00203	.00319	.00430	.00470	.00181
Depreciation	.00193	.00109			
Total cost of distribution	.03192	.03549	.03483	.03605	.047614
Total cost	.08819	.08747	.09128	.09387	.093299
Profit or loss	.00139*	.00425*	.00273*	.00241†	.000155*

* Loss. † Profit.

Dr. Charles E. North gives the figures on cost of milk distribution, shown in Table 122, in his report of the Milk Survey of Kansas City, Mo., published July, 1921. (4)

TABLE 122

COST OF HANDLING ONE QUART GRADE B RETAIL MILK IN VARIOUS CITIES (4)

Cost Items.	New York.	Boston, Average.	Baltimore, Average.	Philadelphia.	Ottawa.	Rochester, Average.	Kansas City.	Hartford.
Country charges	0.008692	0.006139	0.000715	0.011910	.....	.....	0.011076	0.000778
Freight	.009072	.008020	.007500	.007990	0.005000	0.005534	.007658	.011495
Shrinkage	.002656	.003531	.005078	.003930	.000660	.003102	.003500?	.003136
Loss on surplus	.002440	.004237	.....	.....	.002440	.004237	.002000?	.026392
City plant charges	.023182	.017907	.027164	.015480	.010485	.025668	.032199	.022982
City labor charges	.041240	.039915	.030360	.026590	.016642	.026850	.032552	.034280
Administration charges	.000160	.000399	.002311	.002750	.000387	.001337	.001731	.002342
Total	.087247	.076751	.073128	.068650	.035614	.066728	.090716	.101405

Hibbard and Erdman (5) give the following data regarding costs of distribution in Chicago, Illinois, Milwaukee and Madison, Wisconsin, in 1917, indicating "in a general way how total costs are distributed":

TABLE 123

Cost of Milk Distribution (5)

	Cents a Quart.	Per Cent.
Amount paid to farmer	3.276	50.5
Amount paid for transportation	0.489	7.5
Expense for handling at plant	1.172	18.0
Expense of delivery	1.541	24.0
	6.478	100.00

The same authors present the following, based on prices for year ending September 30, 1917:

TABLE 124

The Distribution of the Consumer's Dollar (5)

	Chicago.		Milwaukee.		Madison.	
	Cents.	Per Cent of Retail Price.	Cents.	Per Cent of Retail Price.	Cents.	Per Cent of Retail Price.
Farmer for 1.03 quarts *	4.71	49.6	4.46	54.1	4.41	52.4
Transportation for 1.03 quarts	.58	6.1	.45	5.4	.38	4.5
Dealer or dealers for 1 quart (loss deducted)	4.21	44.3	3.34	40.5	3.63	43.1
Consumer for 1 quart						

* "For each quart the consumer buys, the farmer sells somewhat more than that amount, usually about 1.03 quarts."

To show how the handling of milk in stores would effect the distribution, the same authors (5) present the following:

TABLE 125

DISTRIBUTION OF THE CONSUMER'S DOLLAR (5)

	Milwaukee.		Madison.	
	Cents.	Per Cent of Retail Price.	Cents.	Per Cent of Retail Price.
Farmer for 1.03 quarts	4.46	54.1	4.41	52.4
Transportation for 1.03 quarts	.45	5.4	.38	4.5
Dealer for 1 quart	2.34	28.4	2.63	31.1
Store for 1 quart	1.00	12.1	1.00	12.0
Consumer for 1 quart	8.25	100.0	8.42	100.0

Hoard's *Dairyman* quotes from the Borden Milk Company, regarding the distribution of the consumer's dollar, as follows:

	Per Cent.
Paid to farmer for milk	40.0
Country factory work	5.4
Freight to city	6.7
Trucking to city pasteurizing plant	3.3
Pasteurizing plant work	10.0
Trucking to distributing branch	4.0
Distributing branch expenses	28.0
Remaining for distributor	2.6
	100.0

In Table 126 is given a summary of the costs of distribution for seven large milk dealers in Philadelphia and Baltimore, as reported by the Governors' Tri-State Milk Commission in 1917. (6)

TABLE 126

SUMMARY OF COST DATA FROM THE 1917 REPORT OF THE GOVERNORS' TRI-STATE COMMISSION, ISSUED BY THE MILK COMMISSIONS OF PENNSYLVANIA, MARYLAND, AND DELAWARE, AT HARRISBURG, PENNSYLVANIA (6)

	Total Quarts Handled.	Sold for the Year.		Load per Wagon, Quarts.	Total Cost of Distribution per Quart.
		Wholesale, Quarts.	Retail, Quarts.		
Dealer No. 1.	16,067,676	738,548	14,464,898	285	$0.045
" No. 2.	307,800	199,800	108,000	375–400	.01315
" No. 3.	360,000	180,000	180,000	300	.015
" No. 4.	15,000,000	4,050,000	10,950,000	300	.049
" No. 5.	11,996,151	.....	.....	.....	.028
" No. 6.	27,675,632	1,092,744	13,824,030	300	.0411
" No. 7.	3,283,438	1,189,265	2,094,173	234	.03279

In Table 127 are given the costs of milk distribution in six towns and cities of Massachusetts in 1916, as reported by Cance and Ferguson in Bulletin 173 of Massachusetts Agricultural Experiment Station. (7)

TABLE 127

COMPARATIVE INVESTMENT, COSTS, QAUNTITIES AND CUSTOMERS SERVED IN SIX TOWNS AND CITIES (EIGHTY-SIX DISTRIBUTORS) (7)

City or Town.	Milk and Cream Distributed.				Yearly Cost of Distribution.		Retail.		
	Retail Milk.		Wholesale Milk.	Cream.	Retail Cost.	Cost per Quart. (Cents).	Quarts per Horse.	Quarts per Mile.	Quarts per Customer.
	Daily (Quarts).	Yearly (Quarts).	Yearly (Quarts).	Yearly (Quarts).					
Amherst....	1,050.0	383,250	87,600	10,950	$7,775.73	2.03	175.0	17.9	1.235
Walpole....	1,289.0	470,485	29,200	13,140	10,643.68	2.26	143.2	23.8	1.025
Haverhill...	8,232.0	3,004,680	925,000	22,565	64,769.09	2.16	176.3	21.4	1.299
Pittsfield...	5,508.7	2,010,675	759,200	37,139	46,609.17	2.31	141.2	21.6	1.276
Springfield..	8,612.7	3,143,640	367,350	193,515	96,297.36	3.06	183.2	37.9	1.106
Worcester..	15,809.0	5,770,285	2,523,245	28,829	152,512.03	2.64	170.0	28.0	1.227
	40,501.4	14,783,015	4,691,595	306,138	$378,607.06	2.56			

Tables 128 and 129 and Figs. 136 and 137 show costs of distribution in Detroit, Michigan, in 1915. These costs are, of course, low as compared with costs at present.

TABLE 128

RELATION OF COST OF HANDLING TO CAPITAL INVESTMENTS, SUPPLIES, AND LABOR IN TWENTY-EIGHT CITY MILK PLANTS (9)

Handling Cost per Gallon.* Cents.	Gallons Handled Daily.	Investments.		Supplies.†		Labor.	
		Total.	Per Gallon Handled Daily.	Per Day.	Per Gallon. Cents.	Per Day.	Per Gallon. Cents.
2.3	1600	$13,300	$8.31	$14.96	0.9	$13.68	0.9
2.4	350	4,320	12.34	11.84	1.2	1.99	.6
2.6	9706	267,575	27.57	70.01	.7	167.82	1.7
2.6	2000	16,824	8.41	16.57	.8	27.21	1.4
2.7	850	7,154	9.54	5.48	.7	10.68	1.4
2.8	1450	41,643	28.72	9.76	.7	14.25	1.0
3.1	1450	18,720	12.90	18.42	1.3	17.03	1.2
3.3	220	1,917	8.71	2.45	1.1	3.81	1.7
3.3	340	3,502	10.30	3.24	1.0	5.98	1.8
3.4	470	2,527	5.38	4.87	1.0	9.86	2.1
3.6	400	5,312	13.28	4.20	1.0	7.40	1.9
3.7	165	3,029	18.36	1.95	1.2	2.71	1.6
3.8	2119	97,457	45.99	11.79	.6	47.31	2.2
3.9	425	7,595	17.87	5.61	1.3	7.12	1.7
4.4	335	4,542	13.56	5.43	1.6	5.98	1.8
4.4	100	1,186	11.87	1.64	1.6	2.00	2.0
4.5	310	3,847	12.41	5.18	1.7	5.84	1.9
5.2	230	4,927	21.42	2.35	1.0	7.13	3.1
5.2	1300	7,315	5.63	36.10	2.8	9.97	.8
5.3	100	1,829	18.29	1.18	1.2	2.99	3.0
5.4	240	7,141	29.75	3.70	1.5	6.04	2.5
5.4	530	20,251	38.21	6.76	1.3	10.54	1.0
6.1	135	1,829	13.55	1.57	1.2	5.60	4.1
6.8	85	2,705	31.82	1.24	1.5	3.00	3.5
6.8	1260	110,592	87.77	33.78	2.7	21.80	1.7
7.0	145	4,274	29.48	3.58	2.5	4.70	3.2
7.1	90	2,762	30.69	2.18	2.4	2.56	2.8
7.2	40	1,725	43.13	.51	1.3	1.50	3.8
Average 4.4	940.9	$23,778	$21.97	$10.23	1.4	$15.23	2.01

* These unit costs include charges for depreciation and interest on capital invested, supplies, and labor expenses (all the items which could be definitely charged against handling in plant).

† Supplies include charges for fuel, ice, power and light, bottles, caps, washing powder, brushes, etc.

TABLE 129

Relation of Costs per Quart Delivered to Investments in Delivery Equipment, Average Number of Quarts Delivered per Wagon, and Per Cent of Sales at Retail for Twenty-eight Dealers (9)

Cost per Quart.* Cents.	Investments in Delivery Equipment.		Number of Delivery Wagons.	Average Quarts Delivered per Wagon Daily.	Per Cent of Sales at Retail.
	Total.	Per Gallon Delivered Daily.			
0.5	$1,005.00	$3.24	1	1240	0.0
.8	956.00	4.35	3	293	77.3
.9	1,527.00	9.25	1	660	50.0
1.1	14,899.10	8.92	14	477	54.5
1.2	527.50	4.06	2	260	73.1
1.2	7,280.00	6.31	12	384	62.5
1.2	2,480.00	6.12	4	405	47.1
1.2	8,779.00	6.05	14	414	93.3
1.2	870.00	8.70	1	400	77.2
1.3	2,907.00	12.11	3	320	60.0
1.3	1,180.00	8.74	1	540	77.3
1.3	40,050.85	18.90	14	605	58.9
1.4	170,090.04	17.52	99	392	81.3
1.4	15,055.50	9.45	16	400	53.3
1.4	692.00	8.14	1	340	62.5
1.4	2,096.00	6.45	3	433	76.9
1.4	8,779.00	6.86	14	366	34.5
1.5	3,030.00	10.10	4	300	65.0
1.5	1,160.00	4.64	5	200	50.0
1.5	1,595.50	6.94	3	307	73.8
1.5	575.00	14.38	1	160	85.0
1.6	1,570.00	17.44	2	180	61.5
1.6	2,740.00	8.06	4	340	74.5
1.6	7,375.00	17.35	4	425	65.0
1.7	785.50	7.85	2	200	64.3
1.7	2,623.33	7.83	3	447	71.4
1.8	2,831.50	5.34	6	353	80.0
2.5	29,225.35	23.19	20	252	56.9
1.38†	11,881.75†	9.58†	9†	396†	63.9†

* These unit costs do not include items of administration, office expenses, advertising, licenses, insurance, taxes, and other miscellaneous expenses.

† Average.

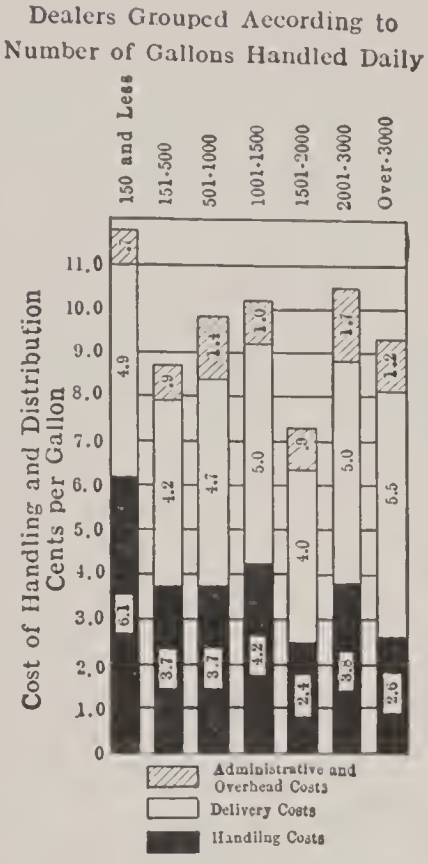

Fig. 136

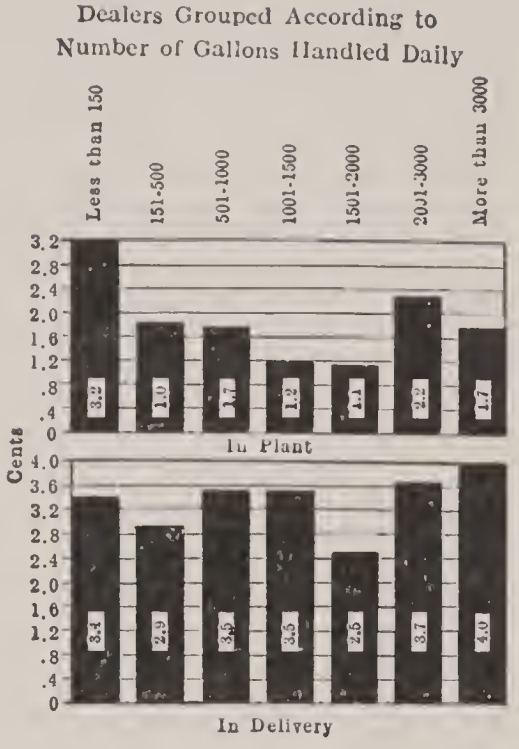

Fig. 137.

Fig. 136.—Cost of handling and distributing a gallon of milk in Detroit in 1915. (9)
Fig. 137.—Variation in cost of labor per gallon of milk. Detroit, 1915. (9)

Table 130 shows the allocation of expenses incurred in marketing milk in Chicago. (8)

TABLE 130

Allocation of Expenses Incurred in Fluid-Milk Marketing in Chicago 1925–1926 (8)

(Based on average yearly milk distribution of approximately 40 million pounds)

	Percentage.	Percentage of Total Expenses.
Labor, salaries and commissions:		
Country	1.68	
Motor transportation	1.81	
City processing	7.91	
General plant	3.76	
Platform	2.85	
Barn	4.13	
Route sales	68.64	
General sales	5.07	
General administration	4.15	
	100.00	65.11

TABLE 130

ALLOCATION OF EXPENSES INCURRED IN FLUID-MILK MARKETING IN CHICAGO, 1925–1926 (8)—*Continued*

(Based on average yearly milk distribution of approximately 40 million pounds)

	Percentage.	Percentage of Total Expenses.
Processing and operating, materials and supplies:		
Supplementary ingredients (chocolate, salt, etc.)	3.87	
Bottles and bottle caps	28.91	
Butter and cheese containers	1.87	
Cans, cases, and crates	6.09	
Ammonia and coarse salt	.19	
Coal	11.74	
Gasoline, oils, and grease	1.37	
Ice	12.09	
Lighting supplies (lanterns, oil, electric bulbs, etc.)	.72	
Cleaning supplies	1.39	
Laboratory supplies	.03	
Small tools	.05	
Tires	.01	
Horse feed, bedding, and miscellaneous	26.40	
Stationery and office supplies	3.90	
Miscellaneous (milk tags, bottle carriers, etc.)	1.37	
	100.00	10.81
Taxes		.72
Insurance		1.07
Depreciation:		
Auto trucks	5.93	
Horses, wagons and equipment	28.38	
Buildings	17.79	
Fixtures	4.24	
Machinery and other dairy equipment	43.66	
	100.00	3.63
Rentals:		
General plant, sales stations, tank cars, barn and stables, etc		.57
Transportation:		
Miscellaneous country and general	.59	
Freight and cartage to city	79.03	
Trucking—city	20.38	
	100.00	9.21
Communication:		
Postage, telephone, and wires		.37
Professional services:		
Collection, legal, accounting and veterinary		.15
Unclassified:		
Country and city processing	6.70	
Memberships and dues	6.70	
Subscriptions and donations	6.05	
Property damaged	1.72	
Interest paid	7.97	
Reserved for bad debts	54.45	
Miscellaneous	16.41	
	100.00	1.75
Advertising		1.65

TABLE 130

ALLOCATION OF EXPENSES INCURRED IN FLUID-MILK MARKETING IN CHICAGO, 1925–1926 (8)—*Concluded*

(Based on average yearly milk distribution of approximately 40 million pounds)

	Percentage.	Percentage of Total Expenses.
Repairs, maintenance and construction supplies:		
Buildings	5.44	
Machinery and equipment	10.36	
Can repairs	1.09	
Autos	1.32	
Furniture, fixtures and equipment	1.77	
Construction materials (lumber, pipe, iron and steel, paints, oils, wire, etc.)	2.33	
Repair parts	2.56	
Horses	24.41	
Wagons	45.32	
Harness	5.40	
	100.00	3.97
Operating services:		
Light	17.62	
Power	25.49	
Water	19.68	
Hauling	4.25	
Messenger	3.40	
Towel service	4.73	
Miscellaneous (auto service, laboratory, calculating, etc.)	24.83	
	100.00	.99
Total expenses		100.00

Table 131 and Fig. 138 show the expenses incurred in marketing fluid milk in four Illinois markets, (8) and Table 132 shows the distribution of the consumer's average purchase price for retail milk in Chicago. (8)

TABLE 131

EXPENSES INCURRED IN MARKETING FLUID MILK IN FOUR MARKETS SUPPLIED BY ILLINOIS PRODUCERS (8)

(Figures indicate percentage of total expenses absorbed by each item.)

	Chicago. 1925–1926.	St. Louis. 1924–1926.	Peoria. 1924–1926.	Quincy. 1924–1927.
Labor, salaries, and commissions	65.11	49.49	43.56	50.94
Processing and operating, materials and supplies	10.81	17.40	12.36	19.04
Taxes	.72	.98	.92	1.49
Insurance	1.07	2.12	2.84	1.47
Depreciation	3.63	8.90	8.43	7.03
Rentals	.57	.93	3.74	
Transportation	9.21	4.97	.59	.09
Communication	.37	.35	.61	.25
Professional services	.15	.56	.77	.44
Unclassified	1.75	6.27	8.20	5.61
Advertising	1.65	1.74	6.39	3.55
Repairs, maintenance, and construction supplies	3.97	4.22	8.91	4.97
Operating services	.99	2.07	2.68	5.12
Total	100.00	100.00	100.00	100.00
Approximate average annual volume (pounds) on which percentages are based	40,000,000	40,000,000	10,000,000	6,000,000

TABLE 132

DISTRIBUTION OF THE CONSUMER'S AVERAGE PURCHASE PRICE FOR RETAIL MILK AND MILK PRODUCTS IN CHICAGO ON THE BASIS OF A QUART OF 3.5 PER CENT MILK (8)

(Based on total retail sales for all volumes, involving an average distribution of approximately 200 million pounds yearly. At least 95 per cent of the sales were retail.)

	Cents.	Cents.
Customer's purchase price		12.9118
Cost of milk		5.3294
Gross margin		7.5824
Purchasing, receiving, and processing expense	2.1968	
Selling and delivery expense	4.5988	
General and administrative expense	.3160	
Total expense		7.1116
Net income		.4708

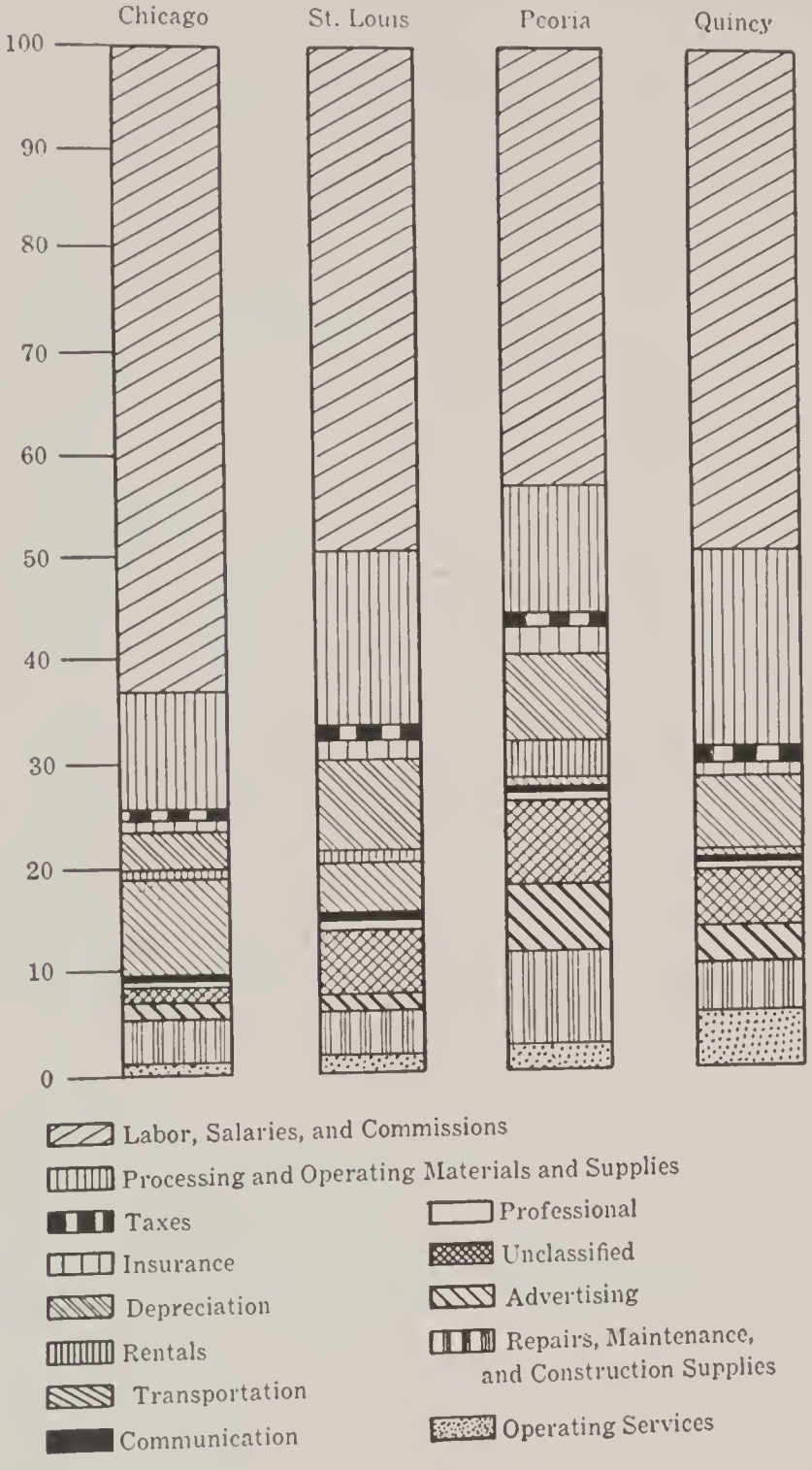

FIG. 138.—Allocation of distribution expenses in four markets. (8). Amounts spent for labor, salaries, and commissions were smallest in Peoria, where much of the milk is delivered by independent route owners. Table 131 shows figures on which graph is based.

Table 133 shows the unit profits and losses on retail milk and cream in Chicago in 1924. (8) It will be noted that there was a loss on milk sold in pints and half pints.

TABLE 133

UNIT PROFITS AND LOSSES ON RETAIL MILK AND CREAM PRODUCTS IN CHICAGO MARKET, 1924 (8)

(The milk and cream included are a part of a total distribution of approximately 150 million pounds of milk; by-products, 200 million pounds.)

Products	Unit Profit or Loss,* Cents	Equivalent per Quart of 3.5 Per Cent Milk
Whole milk:		
Quarts	.752	.752
Pints	−1.560	−3.120
Half-pints	− .936	−3.744
Sweet cream, 22 per cent:		
Half-pints	1.730	
Half-pints, on 3.5 per cent milk base †	.275	1.100
Sweet cream, 32 per cent:		
Half-pints	2.060	
Half-pints, on 3.5 per cent milk base	.225	.900
Cocoa drinks, pints	.893	
Cultured skim milk, quarts	.643	
Cottage cheese, three-quarter-pound cartons	.887	

* Losses are represented with a minus sign before the figures.

† It requires 6.286 quarts of 3.5 per cent milk to make one quart of 22 per cent cream. Since one half-pint of this cream yielded a profit of 1.730 cents, four half-pints yielded a profit of 6.92 cents. Hence, $\frac{6.92}{6.286}$ equals 1.10 cents, which was the profit per quart of 3.5 per cent milk when sold as cream in half-pints at the retail price. Similarly 9.143 volumes of 3.5 per cent milk are required to make a corresponding volume of 32 per cent cream.

Horner (10) has the following to say regarding the cost of distributing milk in Detroit:

"Because of the nature of the milk business much difficulty is found in determining the cost of delivering a quart of milk. Joint costs is one of these peculiarities since, in addition to handling fluid milk, the distributor usually sells sweet cream, buttermilk, and in some instances butter, ice-cream, and cottage cheese. The accounting problem is by no means a simple one to effect the transfer of butter, milk, cream, or skimmed milk from the whole milk to other departments. The following estimate is, however, offered as to the cost of handling milk based on estimates made in Detroit. These figures are for the year 1922.

TABLE 134

COST OF MILK DISTRIBUTION (10)

(45 per cent of Detroit market, 1922)

	Cents.	Cents.
Raw materials (milk)	4.9124	
Receiving station expenses	.2043	
Transportation costs	.5622	
Receiving and weighting	.0553	
Cost delivered to plant	.....	5.7342
Supplies, bottles, cans	.3151	
General manufacturing expense, pasteurizing and bottling	.7223	1.0374
Cost to place on wagon	.....	6.7716
Delivery expense	2.0531	
Selling expense	.0911	
Administrative expense	.3269	2.4711
Total cost—(not including depreciation, interest and other expenses)	.....	9.2427
Depreciation	.1919	
Bad debts	.0341	
Interest cost (expenses—income)	.0207	.2467
Total cost	.....	9.4894
Income per unit	.....	10.5668
Cost before income tax	.....	9.4894
Profit before deducting income tax	.....	1.0774
Income tax	.....	.1066
Net profit per unit	.....	.9708

"It will be noted from the table above that the profit on a quart of milk is on the average less than one cent. Since milk is sold, as a general rule, in even cents per quart, a reduction in the price of milk of one cent per quart would eliminate all profit and therefore cause a loss unless some of the costs were reduced. The margin of gain in distributing a quart of milk is indeed extremely small. The costs of final delivery of a quart of milk as shown above (not including costs of delivering milk to the plant) was 3.7552 cents. This, in other words, is the cost of delivery to the final purchaser."

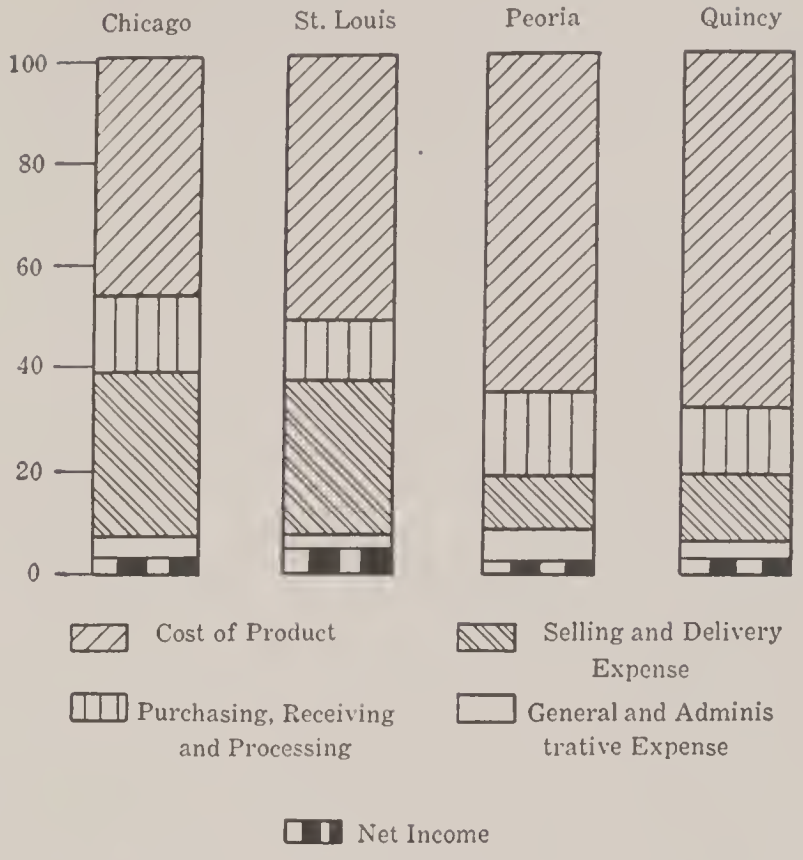

FIG. 139.—Costs and margins in milk distribution in four markets. (8) The total length of each bar represents a sales dollar. In Chicago and St. Louis, where marketing costs are higher, the producer received a smaller part of the consumer's dollar.

Food Industries for October, 1930, gives the cost of distribution for the Borden Milk Company, New York, as follows:

"During 1929 the Borden Company received an average of $0.1593 for each quart of Grade B milk, which latter represents 75 per cent of the company's total volume of fluid milk."

Raw milk (average payment per quart delivered at country plant)		$0.0741
Production expense:		
Labor and salaries for direct plant operation	$0.0059	
Materials	.0025	
Property expense	.0024	
Miscellaneous expense, incl. freight and hauling, etc.	.0103	.0211
Containers: bottles, cases, cans		.0030
Freight and hauling		.0131
Selling expense:		
Wages and commissions	$0.0313	
Materials	.0031	
Property expense	.0048	
Miscellaneous expense	.0040	.0432
General and administrative expense		.0017
Net profit		.0031
Total (average selling price)		$0.1593

MILK PRICES

On the following pages are given data on milk prices paid and received for milk by dealers in various cities of the United States.

REPORT OF FLUID MILK MARKET FOR APRIL, 1931 (12)

Wholesale and Retail Milk Prices at Cities

State.	City.	Dealers' Buying Prices at City for 3.5 Per Cent B. F. Bulk. Cents per Quart.	Selling Price. *				Prevailing B. F. Test of Milk Sold. Per Cent
			On Routes.			At Retail Stores. Bottles. Cents per Quart.	
			Wholesale Trade.		Family Trade. Bottles. Cents per Quart.		
			Bulk. Cents per Quart.	Bottles. Cents per Quart.			
Ala.	Birmingham	6.04–6.45†	.....	11, 05	14	13	4.0–4.6
	Mobile	.....	5–6.25	8	12	10	4.0
Ariz.	Phoenix	.....	7.5	6–10	12	10	
Calif.	Los Angeles	5.27	8.12	10	13	.....	3–6–4.2
	San Diego	6.62–6.77	10–11.25	11–12	13–14	11–14	3.7–4.1
	San Francisco	5.05–5.65	6.25	8	13	11	3.75–4.0
Colo.	Denver	3.57	7.5	7–8	10	8–9	3.6
Conn.	Bridgeport	8.06†	10	13	15	15	
	Hartford	8.06†	11	12	15	15	3.8–4.0
	New Haven	8.06†	11	13	15	15	3.7
Del.	Wilmington	.....	10	12	12	13–14	3.8
D. C.	Washington	7.01–7.48†	10–10.75	11.5–13	14	11–14	4.0
Fla.	Jacksonville	7.07	12	12–12.5	15–16	13–15	4.0–4.8
	Miami	7.46†	13.75	10–15	11–17	12–17	4.0
	Tampa	.....	7.5–12.5	10–13	15	11–15	3.5–4.4
Ill.	Chicago	5.74†	8–9.5	12	13	12–13	3.5
	Peoria	6.02†	8.25	11	13	13	3.7
	Springfield	3.65	6.5	8	9.1	10	3.8
Ind.	Evansville	4.51†	8	9	11	11	3.8
	Indianapolis	3.01–3.57	6.5	8	10	10	3.8
	South Bend	3.76–3.98†	7.5	8	10	10	4.0
Iowa	Davenport	3.98†	7–7.5	8	10	10	3.5–3.8
	Des Moines	4.94†	7.5	9	11	10–11	3.6–3.7
	Dubuque	3.33†	6.5	7	9	8–9	3.7–3.9
	Sioux City	4.29†	7.5	8	10	9–10	3.8
Kans.	Topeka	3.76†	7.5	7–8	8–10	8–10	4.0
	Wichita	2.86–3.40†	6.25	7	9	8–9	3.5
Ky.	Lexington	5.05	8.75	10–12	14	12–13	4.3
	Louisville	3.65†	6.25	8	10	10	3.8–4.0
La.	New Orleans	5.09	8	12	14	14	4.0
Md.	Baltimore	6.60†	9	.....	12		
	Cumberland	5.70†	8.75	11	13	13	4.0–4.4
Mass.	Boston	5.87†	8.25	9.5	12.5	10	
	Fall River	.....	.....	10.5	13	11–13	
	Springfield	6.64†	9	11	14	11–14	3.9–4.0
Mich.	Detroit	5.27†	8.25	9.5	12	10–11	3.6
	Grand Rapids	4.62–4.94†	6.5	8	10	8–10	3.7
	Kalamazoo	4.29–5.05†	7.5	8	10	10	4.0
	Lansing	4.84†	7.5	8	10	10	3.5–3.7
Minn.	Duluth	4.23†	.....	.....	11		
	Minneapolis	3.98†	7.5–7.75	8.5	10	9–10	3.5–3.6
	St. Paul	3.98†	7.5	8.5	10		

REPORT OF FLUID MILK MARKET FOR APRIL, 1931—*Continued*

Wholesale and Retail Prices at Cities

State.	City.	Dealers' Buying Prices at City for 3.5 Per Cent B. F. Bulk. Cents per Quart.	Selling Price.*				Prevailing B. F. Test of Milk Sold. Per Cent.
			On Routes.			At Retail Stores. Bottles. Cents per Quart.	
			Wholesale Trade.		Family Trade, Bottles. Cents per Quart.		
			Bulk, Cents per Quart.	Bottles. Cents per Quart.			
Mo....	Kansas City....	5.37–5.44†	8.75–10	9–10	13	10–13	3.7–3.8
	St. Louis.....	5.48†‡	8.75	10	12	12	3.8
Mont..	Lewistown.....	.....	7.5	8	10	10	3.6
Nebr...	Lincoln.....	3.95	6.5	8	10	10	3.8
	Omaha.....	4.08	7	8	10	.....	3.8
N. H...	Portsmouth....	.....	9	9	12	12	3.9
N. J....	Trenton.....	6.58†	9	11	12	12	3.7–3.8
N. Y...	Albany.....	5.78†	8.5	12	13	15–16	
	Buffalo.....	5.16†	7.5	9–10	12	12	3.6–3.75
	New York.....	6.24†§	10	14	15	15	3.65
	Rochester.....	.....	11	13	13	13	3.7
N. C...	Greensboro.....	6.45	11.25	12.5	15	15	4.0
	Winston-Salem.	6.45†	10–11.25	12	14.25	15	4.1
N. Dak.	Grand Forks...	4.29	7.5	8	10	9	3.5
	Mandan.....	4.29†	8	8.5	11	10	3.8–3.9
Ohio...	Cleveland.....	5.05–5.16†	8	9	11–13	10–12	3.5–3.8
	Columbus.....	4.21†	7–7.5	8	10	9–10	3.5–4.0
	Dayton.....	3.76	8	6–8	10	8–10	3.8
	Toledo.....	3.44–4.08	8.5	9	11	10–11	
Okla...	Oklahoma City.	3.76	7.5	8	10	9	
	Tulsa.....	3.76	7.5–8.75	9	11	10–12	4.0–4.4
Oreg...	Portland.....	3.55†	7.5	8	10–11	10	4.0
Pa.....	Harrisburg.....	5.01†	9	10	12	10–12	
	Philadelphia....	6.64†	10	11–12	12	.....	3.6–3.8
	Pittsburg.....	5.76†	.....	.....	12		
	Scranton.....	5.59	10	11	13	15	3.5–3.7
R. I....	Newport.....	.....	.....	12	14	14	3.9
	Providence.....	.....	9.37	10	12.5	10	3.7
S. Dak.	Sioux Falls.....	3.76	6.25	8	10	10	4.0
Tenn...	Memphis.....	5.01†	.....	.....	13	10–13	
	Nashville.....	.....	7.5	10–12	12	12	
Tex....	Dallas.....	5.59†	8.75	9	12	10	4.0–4.2
	El Paso.....	5.48†	10	11	13	13	3.8
Utah...	Salt Lake.....	3.76	7	8	10	10	3.9
Va.....	Richmond.....	7.72–7.91†	11	13	14	.....	3.8–4.0
	Roanoke.....	.....	11.25	13	15	15	3.8–4.0
Wash..	Seattle.....	3.87†	7	7.5–8.5	10–11	10–11	3.5–4.0
	Spokane.....	.....	7	8	10	10	3.7–4.0
W. Va..	Clarksburg.....	5.37†	8.75	10	12	13	3.8–4.0
	Wheeling.....	4.62†	8.75	9	11	11	3.5–3.8
Wis....	Kenosha.....	6.45	11	11	13	13	3.5–3.6
	Milwaukee.....	5.37†	7	8.5	10	8–10	3.5–3.65
	Racine.....	.....	9.5	9.5	11	11	3.5
	Superior.....	4.23†	8	9	11	11	3.8

* These prices represent grade B milk or the grade which is most commonly sold, the butterfat content varying from 3.5 per cent to 4.8 per cent in different cities.

† Basic prices for fluid milk.

‡ This price applies to part of supply only. Late reports indicate that buying price for part of March supply was 3.87 cents per quart.

§ In the 201–210 mile zone.

PRODUCERS' PRICES FOR STANDARD GRADE MILK TESTING 3.5 PER CENT BUTTERFAT (11)

(Delivered f.o.b. local shipping point or country plant)

Sections.	Range of May Prices.		Prices Compared for Same Markets.			1930 Average for May.
	Number of Local Markets.	Prices per Hundredweight.	Number of Local Markets.	1931 Average for May.	1931 Average for April.	
New England	11	$1.89–3.52	11	$2.71	$2.70	$3.73
Middle Atlantic	18	1.80–2.92	18	2.44	2.46	2.95
E. North Central	25	1.06–2.57	22	1.91	1.97	2.46
W. North Central	22	1.33–2.59	21	1.77	1.85	2.14
South Atlantic	12	2.00–3.29	12	2.73	2.81	3.30
E. South Central	5	1.65–2.20	5	1.99	1.99	2.26
W. South Central	6	1.35–2.20	5	1.76	1.80	2.18
Mountain	5	1.31–3.20	4	2.00	1.99	2.13
Pacific	11	1.15–3.07	10	2.03	2.05	2.26
United States	115	1.06–3.52	108	2.16	2.25	2.65

Above prices include "basic" prices where a surplus plan or pooling plan is in effect. Cities where prices are based upon current butter quotations are not included.

Net Prices Paid Members of Producers' Associations (11)

The following net prices were reported paid to members of producers' associations supplying the cities listed. Prices announced in advance for such cities are usually of two classes, "basic" and "surplus," the former applying to that portion of the milk which is used in fluid form for city wholesale and retail trade, and the latter applying to that portion classed as "surplus," which is used for manufacturing purposes.

Cities.	Last Net Price Paid for 3.5 Per Cent Milk.*	Period for Which Price Was Paid.	Previously Announced Prices for Same Period.	
			Basic.	Surplus.
Hartford, New Haven & Bridgeport, Conn....	$3.06	March	$3.75	Basis current butter markets.
Peoria, Ill.....	1.75	March	2.80	$1.11.
Dubuque, Iowa.....	1.21	April	1.55	Butter market basis.
Baltimore, Md.....	2.87	March	3.54	Basis current butter markets.
Boston, Mass.....	1.652†	March	1.91	Basis current butter markets.
Detroit, Mich.....	2.11	March	2.45	Basis current butter markets.
St. Paul, Minn. and Minneapolis, Minn...	1.50	March	1.85	All milk pooled.
Kansas City, Mo.....	1.95	April	2.50	Basis current butter markets.
New York, N. Y.....	1.84–2.05‡	March	2.90	$1.50–$1.91 depending upon product manufactured.
Akron, Ohio.....	1.62	April	2.30	Basis current butter markets.
Philadelphia, Pa.....	2.874	March	3.09	Basis current butter markets.
Pittsburgh, Pa.....	2.23	March	2.65	Basis current butter markets.
Milwaukee, Wis.....	1.75	April	2.50	Based on butter markets.
Duluth, Minn. and Superior, Wis.....	1.35	Apr. 1–15	1.97	All milk pooled.

* F.O.B. city unless otherwise indicated.

† 181–200 mile zone.

‡ 201–210 mile zone. A net price for April of $1.86 per hundredweight is reported as applying to part of the New York territory.

RETAIL PRICES OF SPECIAL MILK, CREAM, AND BUTTERMILK (12) APRIL, 1931

Cities.	Special Milk, per Quart. Cents.	Certified Milk, per Quart. Cents.	Light Cream (18–25 per Cent B. F.), per Half Pint. Cents.	Cultured Buttermilk, per Quart. Cents.
Boston	16	25	.....	10
New York	18	28	15	
Philadelphia	14–23	30	16–19	12–15
Pittsburgh	.....	25	16–18	
Cleveland	16–25	25	17–20	8–11
Chicago	16	25	15–16	10–20
Minneapolis	.....	22	11	12
St. Louis	16	25	17	10–18
Washington	16–24	30	16–22	13–14
Jacksonville	20	25	15–25	
New Orleans	18	27	17	14
Nashville	14	.....	15	9
Portland	.....	.....	13	10
San Francisco	.....	25	20	13
Average of above cities	17.70	26.00	16.58	12.14

MAY BUYING PRICES FOR "STANDARD GRADE MILK" 3.5 PER CENT B. F. FOR CITIES WHERE PART OF THE SUPPLY IS PURCHASED THROUGH COUNTRY STATIONS (11)

Cities.	Dealer's Buying Prices per Hundredweight of Raw Milk (Flat Prices or 3.5 Per Cent Butterfat Basis).		Freight Zones or Rates to Which Country Station Prices Apply.
	F.O.B. City.	At Country Stations.	
New Haven, Conn.	$3.75*	$3.52*	23¢ rate.
Washington, D. C.	3.26*–3.48*	2.74*	23¢ rate.
Chicago, Ill.	Unavailable	2.32*	All.
Baltimore, Md.	2.84*	2.32*	35¢ rate.
Boston, Mass.	2.74*	1.92*	181–200 mile zone (52¢ rate)
St. Louis, Mo.†	2.55*	2.15*	All.
New York, N. Y.	Unavailable	2.90*	201–210 mile zone.
Cleveland, Ohio	2.35*–2.40*	1.90*–2.13*	All.
Philadelphia, Pa.	3.09*	2.51*–2.55*	51–60 mile zone.
Pittsburgh, Pa.	2.68*	2.03*	All.
Scranton, Pa.	2.40	2.10	30¢ rate.

* Basic prices for fluid milk.

† Applies to part of supply only. These same prices were published in April but later reports indicate that part of the April supply was purchased at $1.60 F.O.B. city and $1.30 country plants.

Note: At all places in the above tables where prices are not shown, the information was either not reported or is not available.

RECEIPTS OF MILK AND CREAM AT NEW YORK, PHILADELPHIA, BOSTON, AND CHICAGO (METROPOLITAN AREAS) FOR THE MONTH OF APRIL, 1931 (40-QUART UNITS) (11)

State of Origin.	Milk.			Cream.			
	NewYork.	Phila-delphia.	Boston.	New York.	Phila-delphia.	Boston.	Chicago.
Arkansas	.....	.....	.....	.....	.....	.....	86
Canada	85						
Connecticut	18,398	.....	281	530			
Delaware	825	43,488	.....	.....	583		
Illinois	.....	.....	.....	.....	.....	.....	21,349
Indiana	.....	.....	.....	.....	6,823	.....	1,027
Iowa	.....	.....	.....	.....	.....	.....	323
Kansas	.....	.....	.....	.....	.....	.....	28
Kentucky	.....	.....	.....	.....	.....	.....	611
Maine	.....	.....	55,187	.....	.....	7,928	
Maryland	9,819	62,807	.....	.....	1,948		
Massachusetts	13,841	.....	52,465	163	.....	84	
Michigan	.....	.....	.....	.....	1,004	1,200	3,688
Minnesota	.....	.....	.....	563	.....	200	
Missouri	.....	.....	.....	.....	403	656	1,955
New Hampshire	.....	.....	65,095	.....	.....	2,039	
New Jersey	77,465	47,955	.....	1,763	95		
New York	1,988,070	.....	47,105	132,544	5,261	10,492	
Ohio	700	.....	.....	1,179	1,502	1,652	582
Oklahoma	.....	.....	.....	.....	.....	.....	16
Pennsylvania	405,907	445,937	.....	18,237	7,252		
Tennessee	.....	.....	.....	.....	.....	1,085	
Vermont	82,375	.....	304,663	9,077	.....	24,125	
Virginia	.....	2,408	.....	.....	1,132		
West Virginia	.....	4,978	.....	.....	336		
Wisconsin	.....	.....	.....	215	7,456	5,997	50,467
Total, Apr., 1931	2,597,485	607,573	524,796	164,271	33,795	55,458	80,132
Total, Apr., 1930	2,782,962	607,710	511,431	149,124	30,501	49,349	*
Jan.-Apr., 1931	10,457,415	2,416,134	2,031,587	585,814	99,507	181,996	297,714
Jan.-Apr., 1930	11,244,333	2,407,668	2,005,861	542,031	106,578	176,688	*

* Not available.

DAIRYMEN'S LEAGUE COOPERATIVE ASSOCIATION
MAY MILK PRICES IN DETAIL (13)

Prices for 3.5 per cent butterfat. Four cents per 100 lb. to be added for each one-tenth of 1 per cent butterfat above 3.5 per cent for Classes 1 and 3; 5½ cents per 100 lb. to be added for each one-tenth of 1 per cent butterfat above 3.5 per cent for Classes 2A and 2B.

Class No. 1—Milk for city consumption.
Class No. 2A—Milk for cream.
Class No. 2B—Milk for plain condensed, ice cream, etc.
Class No. 3—Milk for case goods, whole milk powder, Camembert and hard fancy cheese.
Class No. 4A—Milk for butter. (See footnote.)
Class No. 4B—Milk for American cheeses. (See footnote.)

Miles.	Class 1 Freight Rate per 40-Qt. Can.	Class 1 Freight Allowance per 100 Lb.	Class 1 Metropolitan Area.	Class 1 Elsewhere.	Class 2A (Note 1).	Class 2B.	Class 3.
1 to 10	$ .235	$ .275	$ 3.255	$ 3.625	$ 2.04	2.29	1.99
11 to 20	.245	.285	3.245	3.615	2.04	2.29	1.99
21 to 25	.265	.310	3.22	3.59	2.04	2.29	1.99
26 to 30	.265	.310	3.22	3.59	2.03	2.28	1.99
31 to 40	.275	.320	3.21	3.58	2.03	2.28	1.99
41 to 50	.295	.345	3.185	3.555	2.03	2.28	1.99
51 to 60	.305	.365	3.175	3.545	2.02	2.27	1.98
61 to 70	.320	.370	3.16	3.52	2.02	2.27	1.98
71 to 75	.330	.385	3.145	3.515	2.02	2.27	1.98
76 to 80	.330	.385	3.145	3.515	2.01	2.26	1.98
81 to 90	.340	.395	3.135	3.505	2.01	2.26	1.98
91 to 100	.355	.415	3.115	3.485	2.01	2.26	1.98
101 to 110	.360	.420	3.11	3.48	2.00	2.25	1.97
111 to 120	.370	.430	3.10	3.47	2.00	2.25	1.97
121 to 125	.385	.450	3.08	3.45	2.00	2.25	1.97
126 to 130	.385	.450	3.08	3.45	1.99	2.24	1.97
131 to 140	.395	.460	3.07	3.44	1.99	2.24	1.97
141 to 150	.400	.465	3.065	3.435	1.99	2.24	1.97
151 to 160	.415	.485	3.045	3.415	1.98	2.23	1.96
161 to 170	.420	.490	3.04	3.41	1.98	2.23	1.96
171 to 175	.430	.500	3.03	3.40	1.98	2.23	1.96
176 to 180	.430	.500	3.03	3.40	1.97	2.22	1.96
181 to 190	.440	.510	3.02	3.39	1.97	2.22	1.96
191 to 200	.450	.525	3.005	3.375	1.97	2.22	1.96
201 to 210	.455	.530	3.00	3.37	1.96	2.21	1.95
211 to 220	.470	.545	2.985	3.355	1.96	2.21	1.95
221 to 225	.475	.550	2.98	3.35	1.96	2.21	1.95
226 to 230	.475	.550	2.98	3.35	1.95	2.20	1.95
231 to 240	.480	.560	2.97	3.34	1.95	2.20	1.95
241 to 250	.485	.565	2.965	3.335	1.95	2.20	1.95
251 to 260	.500	.580	2.95	3.32	1.94	2.19	1.94
261 to 270	.505	.585	2.945	3.315	1.94	2.19	1.94
271 to 275	.510	.595	2.935	3.305	1.94	2.19	1.94
276 to 280	.510	.595	2.935	3.305	1.93	2.18	1.94
281 to 290	.515	.600	2.93	3.30	1.93	2.18	1.94
291 to 300	.530	.615	2.915	3.285	1.93	2.18	1.94
301 to 310	.535	.620	2.91	3.28	1.92	2.17	1.93
311 to 320	.540	.630	2.90	3.27	1.92	2.17	1.93
321 to 325	.545	.635	2.895	3.265	1.92	2.17	1.93
326 to 330	.545	.635	2.895	3.265	1.91	2.16	1.93
331 to 340	.550	.650	2.865	3.235	1.90	2.15	1.92
341 to 350	.565	.655	2.88	3.25	1.91	2.16	1.93
351 to 360	.570	.665	2.865	3.235	1.91	2.16	1.93
361 to 370	.575	.670	2.86	3.23	1.90	2.15	1.92
371 to 375	.580	.675	2.855	3.225	1.90	2.15	1.92
376 to 380	.580	.675	2.855	3.225	1.89	2.14	1.92
381 to 390	.590	.685	2.845	3.215	1.89	2.14	1.92
391 to 400	.595	.690	2.84	3.21	1.89	2.14	1.92
401 to 410	.....	.....	2.84	3.21	1.88	2.13	1.91
411 to 420	.....	.....	2.84	3.21	1.88	2.13	1.91
421 to 425	.....	.....	2.84	3.21	1.88	2.13	1.91
426 to 430	.....	.....	2.84	3.21	1.87	2.12	1.91
431 to 440	.....	.....	2.84	3.21	1.87	2.12	1.91
441 to 450	.....	.....	2.84	3.21	1.87	2.12	1.91
451 to 460	.....	.....	2.84	3.21	1.86	2.11	1.90
461 to 470	.....	.....	2.84	3.21	1.86	2.11	1.90
471 to 475	.....	.....	2.84	3.21	1.86	2.11	1.90
476 to 480	.....	.....	2.84	3.21	1.85	2.10	1.90
481 to 490	.....	.....	2.84	3.21	1.85	2.10	1.90
491 to 500	.....	.....	2.84	3.21	1.85	2.10	1.90

Note 1: These are the base prices without reference to skim milk value. If no profitable disposition is made of the skim 10 cents per 100 pounds is to be added to prices stated.

Milk used in the manufacture of butter and American cheese will be paid for under Class 3 as provided in schedule of prices for month. The Class 4A price for 3 per cent milk without skim value is $1.04 and the 4B price $1.16.

Sheffield Farms Company price for 3 per cent Grade B milk in the 200–210 mile zone for May, 1930, $1.94½.

COST ACCOUNTING FOR MILK PLANTS

There is no uniform system of accounting for milk plants. As shown in the cost figures given, there is a great variation in the cost items used and in the allocations of the costs to different departments. In 1917 the U. S. Food Administration made an investigation of the cost of milk distribution and considerable effort was made to devise forms for collecting the costs. The form that was finally developed, after consultation with various accountants and experts, is shown.

UNITED STATES FOOD ADMINISTRATION

WASHINGTON, D. C.

INFORMATION AS TO MILK DISTRIBUTION

Return to MILK COMMITTEE, United States Food Administration

No. 1. ASSETS

INSERT below, in accordance with the general classification given, your assets as of June 30, 1917

	City.	Country.	Total.
OPERATED PROPERTY:			
Land			
Buildings			
Machinery			
Teams, Auto Trucks, etc.			
Other			
INVESTMENTS:			
Liquid Assets			
Intangible Assets, Good Will, etc.			
Other Assets (itemize):			
Total (*Per books*)			

II. Sales, Costs, and Net Earnings

Insert, in so far as is practicable, the data called for below:

	Six Months Ended June 30, 1917.	Month of July, 1917.	Month of August, 1917.
Total quarts of milk purchased			
Total amount paid to farmers for milk	$	$	$
Net sales, in quarts			
Net sales, in value	$	$	$
Country Cost:			
Handling, Depreciation, etc	$	$	$
Ice, collecting station only			
Freight	$	$	$
Total			
Factory Expenses:			
Cartage, railroad station to plant	$	$	$
Bottling and Pasteurization			
Ice, Fuel, and Supplies			
Depreciation			
Total			
Delivery Expenses:			
Horse and Wagon Maintenance	$	$	$
Auto Truck Maintenance			
Drivers			
Stable, etc			
Depreciation			
Container Loss			
Miscellaneous			
Total			
Selling, Administration, and General Expenses:			
Advertising and Soliciting	$	$	$
Insurance and Taxes			
Salaries of Executives			
Other Salaries, Office Expenses, etc			
Total			
Total Cost and Expenses	$	$	$
Net Earnings	$	$	$
Ratio to Net Sales	%	%	%

III. The depreciation charges included above for the six months ended June 30 1917, comprise the following detail:

	Country.		City.	
	Amount.	Per Cent.	Amount.	Per Cent.
Buildings	$		$	
Plant Equipment:				
Refrigeration				
Milk Machinery				
Power				
Teams and Equipment				
Autos and Equipment				
Bottles				
Cases				
Cans				
Others (itemize)				
Total	$		$	

IV. Disposal Made of the Supply of Milk Purchased

Total quarts of whole, or market, milk purchased { 6 months to June 30, 1917..... / July, 1917..... / August, 1917.....

Insert below the per cent (%) of total purchases for each price at which milk was sold, for instance:

"29%, 11 cents, Family."
"30%, 9 cents, Restaurant."

	Six Months Ended June 30, 1917.			Month of July, 1917.			Month of August, 1917.		
	Per Cent of Total.	Price at Which Sold.	Class of Trade.	Per Cent of Total.	Price at Which Sold.	Class of Trade.	Per Cent of Total.	Price at Which Sold.	Class of Trade.
.....	.....	$.....	.....	.....	$.....	.....	.....	$.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Donated as gratis milk.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Loss or shrinkage...	.....	.....	.....	.....	.....	.....	.....	.....	.....
Used as surplus in cream and other by-products as shown below.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

V. Uses of Surplus Milk

	Six Months Ended June 30, 1917.			Month of July, 1917.			Month of August, 1917.		
	Quarts of Milk Used.	Quantity Each Product Produced.	Gross Value of Quantity Produced.	Quarts of Milk Used.	Quantity Each Product Produced.	Gross Value of Quantity Produced.	Quarts of Milk Used.	Quantity Each Product Produced.	Gross Value of Quantity Produced.
Butter.....	.....	.....	$.....	.....	.....	$.....	.....	.....	$.....
Cream.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Buttermilk.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Skim milk.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Condensed milk....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Milk powder.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cheese.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	.....	.....	$.....	.....	.....	$.....	.....	.....	$.....

VI.	Six Months Ended June 30, 1917.	Month of July, 1917.	Month of August, 1917
Number of Retail Routes			
Average Number of Quart Points per Route			
Number of Wholesale Routes			
Average Number of Quarts per Route			

VII. Per Cent of Bottles Lost

a. Not returned by customers.....
b. Broken in plant.....

VIII. What Means are Used To—

a. Increase returns of bottles from consumers.....
b. Decrease breakage in plants.....

IX. Any Suggestions as to How Milk Distribution Costs can be Lowered or Other Data or Suggestions for the Consideration of the Food Administration

The foregoing has been prepared from our books and accounts and, in my opinion, is correct

.....

By.....
(Name and position of signer.)

REFERENCES

(1) Hoard's Dairyman, Vol. 58, page 1256.
(2) The Production, Distribution and Food Value of Milk: A report to Herbert C. Hoover, U. S. Food Administrator, by the Milk Committee, Clyde L. King, Chairman, 1918.
(3) Report of the Mayor's Committee on Milk, City of New York, December, 1917.
(4) North, Dr. Chas. E., Report of Milk Survey and Ordinance, Kansas City, Mo., July, 1921.
(5) Bul. 285, Wisconsin Agri. Exp. Sta.
(6) Report of the Governor's Tri-State Commission, by the Milk Commissions of Pennsylvania, Maryland and Delaware, 1917.
(7) Canee, A. E., and Ferguson, R. H., The Cost of Distributing Milk in Six Cities and Towns in Massachusetts, Bul. 173, Massachusetts Agri. Exp. Sta., May, 1917.
(8) Brown, C. A., Costs and Margins and other Related Factors in the Distribution of Fluid Milk in Four Illinois Market Areas. Ill. Agri. Exp. Sta. Bul. 318, 1928.
(9) Clement, C. E. and Warber, G. P., The Market Milk Business of Detroit, Michigan, in 1915, U. S. Dept. Agri. Bul. 639, February 15, 1918.
(10) Horner, J. T., The Detroit Milk Market., Mich. Agri. Exp. Sta. Special Bul. 170, 1928.
(11) Fluid Milk Market Reports for the U. S., May, 1931, U. S. Bureau of Agri. Economies.
(12) Report of the Fluid Milk Market for April, 1931—"Crops and Markets," issue of April, 1931.
(13) American Creamery and Poultry Produce Review. June 25, 1930.
Erdman, H. E., The Marketing of Whole Milk, The Macmillan Company, New York, 1921.
King, Clyde L., The Price of Milk, 1920.
Monthly Fluid Milk Price Reports of the U. S. Bureau of Markets.
The Milk Question in New England, Boston Chamber of Commerce, December 31, 1917.
Investigation and Analysis of the Production, Transportation, Inspection and Distribution of Milk and Cream in New England, Boston Chamber of Commerce, July, 1915.

APPENDIX

THERE are outlined herewith a series of practicums arranged for use in connection with the various chapters. It may not be possible to follow these practicums in their entirety; but it is thought that they will serve as suggestions to teachers and advanced students. If certain practicums are not feasible on account of local conditions, others may be expanded into two periods, or new ones devised to take their places.

A number of the practicums are inadvisable without the cooperation or permission of health authorities, farmers and milk dealers. Arrangements should be made with such parties well in advance, so that no difficulty will be encountered.

PRACTICUMS

Practicum I. Dairy Statistics.—An extended review of the literature cited will be of interest in connection with this chapter. Students may also secure information from their own and adjacent towns regarding the amount of market milk used daily. From these data and population figures, the per capita consumption of milk can be estimated.

Practicum II. Food Value of Milk.—Review the literature cited. Problems may be given the students involving the protein and energy requirements of individuals, and the amount of milk necessary to fulfill them. Where there are depots for the modification of milk for infant feeding, they may be visited for the observation of methods of modification, delivery, etc.

Practicum III. Milk and Public Health.—Bacteriological, chemical and physical examination of farm water-supplies may be carried on in connection with other courses. Visits to certified dairies should be made to observe precautions taken against spread of communicable diseases. Students should particularly note methods and reports of medical examination of employees, toilet arrangements, milk-house screens, etc.

Practicum IV. Chemistry.—It is expected that practicums for this chapter will be held in connection with chemistry or milk-testing courses.

Testing milk for fat, solids, specific gravity, refraction, etc., should be included. The advanced student will find many problems to study, connected with changes in the chemical composition of milk, the ratios of the component parts, etc.

Practicum V. Bacteriology.—Practicums in connection with this chapter are given in bacteriological courses. They cover the various methods of counting and differentiating organisms in milk. Work may be done on the thermal death point of milk organisms.

Practicum VI. Clean Milk Production.—Several periods may be devoted to clean milk competitions between the students. The competitors, working singly, may each use their best efforts to produce milk of a low bacterial count. Each student should be given perfect freedom in preparing the cow, utensils, etc., for milking. Samples should be taken for bacterial analysis. An honor roll may be established for clean milking. Collectively, the class may undertake experiments covering the relative effect on the bacterial count of major dairy operations.

Practicum VII. Dairy Laws.—Copies of city and state dairy laws should be secured and studied, to see how they could be simplified. The student should note whether or not all essential features are covered, and substitute simple phrases for involved or indefinite sentences.

Practicum VIII. Dairy Inspection.—This subject should cover a number of inspection trips to dairy farms. It is better to start with a very good dairy, so that a high standard may be implanted in the students' minds. Subsequent inspections should be made of average and poor dairies. The instructor should demonstrate scoring with the score-card at the first two or three farms. Afterwards, each student should work independently. Scores may then be compared and explanations made. In scoring, personal observation should be made of all points possible.

Practicum IX. City Inspection.—A number of city milk plants should be inspected and scored with the score-card. The same procedure may be used as in the case of dairy farms. Both raw milk and pasteurized milk should be scored. Bacterial counts may be made on cans and bottles, by the system described, and, if possible, tests of pasteurizing efficiency should be carried on. Several stores may be visited to observe how milk is cared for. Samples of milk can be secured and tests run for fat, solids, and sediment. Other tests of milk, as described, may be taught in this course or correlated courses.

Practicum X. Scoring Milk and Cream.—This work should include several periods devoted to judging milk and cream for flavor and odor, sediment and appearance. A set of standard samples, from which students can get a definite ideal, may be prepared. Defective samples

may then be judged. Special drills should be given in detecting feed and manurial contaminations, as affecting flavor and odor. Sediment should be scored and described.

Practicum XI. Cost of Milk Production.—Data may be secured from neighboring farms or from the college dairy. Labor operations may be observed and actually timed. Feed for dairy cows can be weighed at several milkings. The amount of milk produced should also be noted. Estimates may be made of the value of cows, buildings and equipment. Tables may be prepared showing the feed cost of the milk produced. Advanced students may go more thoroughly into the subject, spending some time during the summer in making more complete studies.

Practicum XII. Methods of Supplying Consumers with Milk.—Visits may be made to both small and large towns, and observations made on the methods used in getting the milk to the consumer. Observations should be made at city milk plants and at the headquarters of the village milk dealers. The trip to the city milk plants, however, should be deferred until Practicums XVI, XVII and XVIII are taken up. Observations should also be made upon the method of paying for dealer's milk, and upon methods of delivery in the case of the producer-dealer.

Practicum XIII. Producers' Cooperative Milk-distributing Organizations.—If there is a producers' cooperative milk plant near by, it may be visited by the students. Copies of by-laws should be obtained if possible and they, as well as the by-laws appearing in the Appendix, should be studied by the students.

Practicum XIV. The Transportation of Milk.—Students should be detailed to follow, from the farm to the city, shipments of milk sent by truck and railroad. They should take temperatures of the milk along the route, note delays at shipping points, city terminal and city plant. Notations should also be made of any losses that occur along the route. Certain cans should be selected for the purpose of determining the loss. The cans of milk should be checked with producer's manifest at the country, and notations should be made when they are put on the train, on arrival at city terminal and again at city plant. The credit given at weigh can should be compared with quantity received by gallon or measure.

Practicum XV. Country Receiving Stations.—If possible, a country receiving and cooling station should be visited and methods of operation noted. Each student should make a list of all the equipment.

Practicum XVI. The City Milk Plant—Construction and Arrangement.—A floor plan for a one-story plant, to handle about 500 gallons of milk

daily, should be drawn by each student, showing the location and arrangement of machinery and dimensions of rooms. Each piece of equipment should be placed on the plan. Similar plans should be drawn for a two-story plant to handle about 2500 gallons of milk daily. Visits should be made to city milk plants and observations made as to the construction of buildings, floors, walls and ceilings. Students should also note arrangement of machinery, division of rooms, arrangements for receiving milk, loading and unloading delivery wagons. Time studies may be made of these latter operations.

Practicum XVII. Milk Plant Equipment.—During the visits to the milk plants in connection with Practicum XVI, each student should make a list of all the equipment in the plants and should write a report showing the use and the approximate cost of each piece of equipment. Prices may be obtained from catalogues.

Practicum XVIII. Milk Plant Operation.—Practical experience in the various operations in a milk plant should be obtained at the college dairy or at a commercial plant, when possible. Experience should be had in such operations as weighing and grading milk, balancing the stock for the day, washing bottles, filling and capping, checking delivery wagons in and out, etc. Time studies should be made, when possible, of such operations as washing bottles, washing cans, filling and capping, etc., to determine the man-hours used per unit of production.

Practicums XIX and XX. Pasteurization of Milk.—Practical experience should be had in the operation of pasteurizers of as many types as possible. Students should make accuracy tests on continuous-flow holders; and observations on the accuracy of automatic compartment holders. Observations should be made and records turned in, of the operation of temperature recorders and automatic temperature control. Temperatures obtained with regeneration pasteurizers, at entrance and outlet of regenerater cooler and of the pasteurizer, should be observed and recorded. Practical experience should be had in cleaning the pasteurizer and other apparatus.

Practicum XXI. Special Practices.—Various problems in standardizing should be presented by the instructor. The following are illustrative examples—(1) How much 30 per cent cream can be made from 10 gallons of 40 per cent cream and skim milk? (2) How much, if 4 per cent milk is used instead of skim? (3) Using 40 per cent cream and 25 per cent cream, show by diagram the proportions to use to made 30 per cent cream. (4) Same, using 40 per cent cream and 4 per cent milk. (5) Same, using 30 per cent cream and skim milk.

Student should observe operation of clarifiers, emulsifiers and homogenizers, and should make bacterial counts on milk before and after

clarification. If possible, they should also observe the effect, on the product, of different pressures used on the homogenizers.

Practicum XXII. Mechanical Refrigeration.—Observations may be made of the operation of compressors in milk plants, noting the pressures used, etc.

Practicum XXIII. Milk Delivery.—Practical experience on a delivery wagon is desirable, whenever possible. Students should obtain data at city plants as to size of loads carried, number and kind of packages delivered; also, if possible, each student should make an actual study of a route, noting time out, time wagon is moving, time standing still, number of packages delivered per stop, etc.

Observations should be made on methods used in checking the driver in and out, and on the method used by the driver to account for the goods charged to him each day.

Practicum XXIV. Cost of Milk Distribution and Milk Prices.—Students should make a careful study and analysis of the cost figures that are given in Chapter XXIV, also obtain and study as many as possible of the bulletins given under references.

Copies of the current issues of the "Monthly Fluid Milk Market Report" issued by the U. S. Bureau of Agricultural Economics, should be obtained for each student. From these reports students should determine prices per quart paid by dealer, and the spreads for different cities between prices paid by dealer and prices received from family trade and from stores. The larger cities should be listed in the order of highest prices paid by the dealer, highest prices received from family trade, and also in the order of the spread between prices paid by dealer and prices received from family trade.

METHODS AND STANDARDS FOR THE PRODUCTION AND DISTRIBUTION OF "CERTIFIED MILK"*

Definition.—Certified Milk is the product of dairies operated in accordance with accepted rules and regulations formulated by authorized Medical Milk Commissions to insure its purity and adaptability not alone for infants but for children during the entire period of growth. It also has special qualifications to meet the requirements of the expectant mother, as a galactagogue during the period of lactation, and as a food for invalids.

Need.—The need for a purer milk was experienced primarily by those engaged in the conservation of the life and health of infants. As a result there was formulated in 1892 a plan whereby Certified Milk would be produced by a dairyman under the control of a Medical Milk Commission designated by a representative medical society.

* Adopted by the American Association of Medical Milk Commissions, Inc., June 24, 1930.

First Rules.—The first rules designed for this purpose were those contained in an agreement entered into by a Medical Milk Commission and the dairyman concerned.

The rules contained in the original agreement mentioned, represented the essential requirements for the production of Certified Milk. Following this precedent, other Commissions were organized, which, in 1906, became federated into a national association known as the American Association of Medical Milk Commissions, Inc.

Objects.—A fundamental object of this Association was to bring about the uniformity of standards and their perfection. This result has been approximated by the adoption from time to time of definite standards relating to the veterinary inspections of herds, the sanitary inspections of the farms and their equipment, the medical inspection of employees handling the milk, and the bacteriological and chemical examinations as to quality and purity. The Association recommends these methods and standards to component Commissions as ideal and to be as closely approximated as possible.

ORGANIZATION OF MEDICAL MILK COMMISSIONS

A Medical Milk Commission is appointed by a representative official County Medical Society and acts under its auspices and for it, to encourage the production of milk of the highest possible standards of purity. The Commission should include at least five members and become responsible for the carrying on of the following divisions of work: (*a*) the hygiene of the dairy, as it relates to the production and distribution of the milk; (*b*) the veterinary supervision of the herd; (*c*) the medical supervision of the employees; (*d*) the chemical and bacteriologocal examinations of the milk.

DUTIES OF THE COMMISSION

After its organization the Commission should designate a sanitary inspector, a veterinarian, a physician and an analyst to enforce its methods and standards. Any two of these positions may be filled by the same person if properly qualified. These officers shall be required to render regular reports of their inspections and examinations. An agreement written or otherwise may then be entered into with any dairyman who is desirous of undertaking the production of Certified Milk. Upon investigation of such plant and upon receipt of favorable reports from the several experts, the dairyman should be authorized, in accordance with the terms of agreement, to employ the term "Certified Milk." Such Commissions shall report promptly to the secretary of the American Association of Medical Milk Commissions, Inc., in order that no delay be experienced in securing approved seals for the bottles.

The Commission's certification shall continue as long as its standards and requirements are maintained. The Milk Commission reserves the right to change its standards within reasonable limits upon due notice being given the Producers and Distributors.

HYGIENE OF THE DAIRY BUILDINGS

1. Location of Buildings.—Buildings in which Certified Milk is produced and handled shall be so located as to insure proper shelter and good drainage, and at sufficient distance from other buildings, dusty roads, cultivated and dusty fields, and all other possible sources of contamination; provided, in the case of unavoidable proximity to dusty roads or fields, suitable arrangements shall be made to exclude dust.

2. Surroundings of Buildings.—The surroundings of all buildings shall be kept clean and free from accumulations of dirt, rubbish, decayed vegetable or animal matter or animal waste, and the stable yard shall be well drained. All fly-breeding places shall be eliminated.

MILKING STABLES

3. Construction of Milking Stables.—The milking stables shall be constructed so as to facilitate the prompt and easy removal of waste products. The floors and platforms shall be made of cement or other non-absorbent material, and the gutters of cement only. The floors shall be properly graded and drained, and the manure gutters shall be from 6 to 8 inches deep and so placed in relation to the platform that manure will usually drop into them. The inside surface of the walls and all interior construction shall be smooth, with tight joints, and shall be capable of shedding water. The ceiling shall be of smooth material and dust-tight. Horizontal and slanting surfaces which might harbor dust shall be avoided as far as possible. When cows are kept in a separate stable between milkings, this stable shall be so constructed as to provide proper shelter. The floors shall be kept dry and reasonably clean.

4. Condition of Milking Stable.—The milking stable shall be kept scrupulously clean. Interior walls shall be light in color. The walls and ceilings shall be whitewashed often enough to keep them clean and white, at least twice a year, unless such walls and ceiling are of smooth cement finish or painted so that they can be washed frequently.

5. Drinking and Feed Troughs.—Drinking troughs or basins, and feed troughs and mixing floors shall be kept in a clean and sanitary condition at all times.

6. Stanchions.—Stanchions shall be of modern type and of sanitary construction. When another method of fastening is used it shall be arranged so that the droppings will fall for the most part into the gutter. Provision shall be made to keep cows standing between cleaning and milking.

7. Ventilation.—Cow stables shall be sufficiently insulated and also provided with a workable and adequate system of ventilation so that one will not notice a stale, disagreeable or strong animal odor on entering the building, or excessive condensation of moisture, and each cow to be provided with a minimum of 600 cubic feet of air space.

8. Windows.—A sufficient number of windows shall be installed and so distributed as to provide satisfactory light and a maximum

of sunshine; 4 square feet of window area to each 600 cubic feet of air space to represent the minimum. Windows shall be kept free from dust and dirt.

9. Exclusion of Rats and Other Vermin.—All necessary measures should be taken to prevent the entrance of rats and other vermin into stables and dairy buildings, and proper methods adopted for their destruction if they gain access.

10. Extermination of Flies and Other Insects.—In addition to the elimination of fly-breeding places as provided in paragraph 2, the frequent extermination of flies and other insects in milking stables shall be accomplished by spraying or equally effective methods.

11. Visitors.—Visitors shall be so conducted through the stables and dairy buildings as to eliminate opportunities for contaminating the milk and shall be excluded from all rooms in the dairy building where milk, sterilized bottles or equipment is exposed. Children shall not be allowed in the dairy building nor in the stable during milking.

MILK-RECEIVING ROOM

12. Milk-Receiving Room.—The milk-receiving room shall be held to mean any room or building established at or near the milking stables and used for the purposes of a central collecting room for milk as brought from the stables. Such room shall be provided and shall conform to the same rules as to construction, maintenance and cleanliness as applies to the milk-bottling room in the bottling plant, and shall not be directly connected with the stable.

In each receiving room or adjacent room, running water or water with foot or arm controlled faucets, soap (preferably liquid) and individual (preferably paper) towels shall be provided for the use of milkers.

DAIRY BUILDING AND EQUIPMENT

13. Dairy Building.—A dairy building shall be provided which shall not directly communicate with the stables or dwelling. There shall be no open manure storage or other source of contamination at a higher level or within 600 feet of it. The building shall contain separate rooms (suitably equipped) for handling and bottling Certified Milk or products made therefrom and for washing and sterilizing the utensils and bottles, together with a separate boiler room. Necessary cooling facilities with proper mixing tanks shall be provided. The walls and ceilings of the dairy building shall be constructed of nonabsorbent material. It shall be kept clean and shall not be used for purposes other than the handling and storing of Certified Milk and its products and milk utensils. It shall be provided with light and ventilation, and the floors shall be of concrete or any other impervious material properly graded and water-tight.

The dairy building shall be well lighted and properly screened, and drained through well-trapped pipes. No animals shall be allowed therein. No part of the dairy building shall be used for dwelling or lodging purposes, and the bottling room shall be used for no other pur-

pose than to provide a place for clean milk utensils and for handling the milk. During the bottling this room shall be entered only by persons employed therein or official inspectors. The bottling room shall be kept scrupulously clean and free from odors. Adequate lavatory facilities shall be provided. Any water closets or urinals in this building shall be of approved sanitary design and installation and shall not communicate directly with the milk handling rooms. Water closets or urinals shall be kept scrupulously clean and shall be provided with lavatory facilities.

14. Utensils.—All utensils shall be constructed so as to be easily cleaned, the milk pails shall preferably have an elliptical opening 5 by 7 inches in diameter. The top of the pail should be so convex as to make the entire interior visible and accessible for cleaning. Pails shall be of heavy tin plate, or other chemically inert metal with all seams made flush. All utensils used in handling milk shall be kept in good repair and as free as possible from rust.

15. Cleaning and Sterilizing of Bottles and Utensils.—The dairy building shall be provided with approved apparatus for cleansing and sterilizing all bottles and utensils used in milk production. Thermometers shall be used on all sterilizers to record or indicate temperatures and such thermometers shall be checked at least once a week by a standard tested thermometer and record of such checking shall be kept on file at the farm for a period of at least six months. All bottles and utensils shall be thoroughly cleaned by hot water and a strong solution of salsoda or an equally effective cleansing agent, rinsed until the cleaning water is thoroughly removed, then sterilized by steam, dry heat, boiling water or any other approved method and kept inverted in a place free from dust and other contaminating materials until used. By any method used, the final test of sterility and cleanliness shall be freedom from bacteria, chemical re-agents and any other foreign matter.

16. Milking Machines.—Milking machines shall be rinsed with clean, cold water immediately after use. They shall be so dismantled that all parts may be thoroughly cleaned, then rinsed with clean hot water, steam or other satisfactory method. (When chemical sterilization is used, machine shall be thoroughly rinsed with sterile water just before use.) All rubber parts shall be maintained in serviceably sound condition.

17. Water Supply.—The entire water supply shall be absolutely free from contamination, and shall be sufficient for all dairy purposes. It shall be protected against flood or surface drainage. The purity of each source of supply shall be checked by bacteriological examination according to standard methods at equal intervals at least three times a year and as often in addition as conditions indicate it to be necessary and a record of such examinations be filed at the farm for a period of one year. When the water supply is obtained from municipal supply, the records of the municipality or state may be accepted in lieu of above. Samples for such examinations shall be collected at the source (if on the farm) and after passage of the water through storage tanks, if any. A chemical analysis shall be made annually.

18. Nuisances.—No privy or water closet other than of the modern flush type shall be allowed on a certified dairy.

HERD MANAGEMENT AND STABLE PRACTICES

19. Pastures or Exercising Paddocks.—Pastures or exercising paddocks for the cows shall be provided. They must be sufficiently distant from all offensive conditions to suffer no bad effects from them. Pastures shall be free from infectious agents and plants which might affect the milk deleteriously.

20. Exclusion of Animals from the Herd.—No horses, hogs, dogs, or other animals or fowls shall be allowed to come in contact with the Certified herd. All cows kept in the same barn with the milking cows shall receive the same supervision and care. Three-teated cows shall be excluded from the Certified herd.

21. Bedding.—No moldy hay or straw, bedding from horse stalls or other unclean materials shall be used for bedding the cows. Only bedding which is clean, dry, absorbent, and reasonably free from dust may be used.

22. Cleaning the Milk Stable and Disposal of Manure.—Soiled bedding and manure shall be removed from the milking stable at least twice daily, and the floors shall be swept and kept free from refuse. Such cleaning shall be done not less than one hour before the milking time. Manure, when removed from the stable, should be hauled directly to the field.

23. Clipping.—Long hairs shall be clipped from the udder and flanks of the cow, and from the tail above the switch. The switch should be cut to clear the ground or platform by at least four inches. If this is not desirable with pure-bred animals then the switch shall be washed often enough to keep it clean and shall be brushed thoroughly before each milking.

24. Cleaning of Cows.—Each cow in the milking stable shall be carefully groomed before each milking, all dry or wet manure, mud, or other dirt being removed. The dry material shall be loosened with a curry comb and thoroughly brushed out with a stiff brush, and the wet material remaining after brushing shall be washed off with a clean cloth and clean water. The brushing shall be completed a half hour before milking. Special attention shall be given to the udder and flanks. After the udders are brushed clean they shall be wiped with a clean, damp cloth, or they may be washed. If washed, they should be wiped with a dry clean cloth. It is recommended that a freshly washed individual towel or the fresh surface of a folded towel be used for each cow.

25. Feeding.—All foodstuffs shall be kept in an apartment separate from the cow stable. They shall be brought into the stable only immediately before the feeding hour, which shall follow milking. Only those foods shall be used which consist of clean, palatable, and nutritious materials, such as will not injure the health of the cows or unfavorably affect the taste or character of the milk. No dirty or moldy food, or food in a state of decomposition or putrefaction shall be fed. A well-balanced ration shall be used, adequate in vitamin and mineral content, and all changes of food shall be made slowly. The first few feedings of grass, alfalfa, ensilage, green corn, or other green feeds shall be given in small rations and increased gradually to full ration.

26. Exercise.—It is recommended that all dairy cows be turned out for exercise at least 2 hours in each 24 in suitable weather.

27. Inspection.—An inspection of the hygiene of a dairy shall be made at least once a month by the designated representative of the Milk Commission.

VETERINARY SUPERVISION OF THE HERD

28. Tuberculin Tests.—When application is made for the certification of the milk of a herd, a tuberculin test of the herd shall be made and if any of the animals react, a second test shall be made within 60 to 90 days. Thereafter, the herd shall be tested semi-annually. If no reactions are found on the first test, the second test shall follow in six months. If the entire herd has been subjected to a tuberculin test within 60 days prior to the receipt of the application, this may, if satisfactory, be accepted as the primary test.

29. Methods of Application.—The subcutaneous and intradermal methods of applying the tuberculin test shall be used alternately in the tests prescribed in paragraph 28. The ophthalmic method shall be used as an adjunct to whatever method is used on the 60-90-day test and it is recommended that this method be used in conjunction with the subcutaneous or intradermal methods on all tests. Each animal shall be subjected to a physical examination when tuberculin tested. When the subcutaneous method is used all animals in the herd shall be included in each herd test except calves under 6 months of age and animals over this age which have been tuberculin tested within 60 days, and when the intradermal method is used all shall be included except animals which have been tested within 60 days. The latter shall be tested 60 to 90 days after the previous test if conditions require it. No new animals shall be brought on the farm without first having passed a satisfactory physical examination and tuberculin test within 60 days, and, unless from a herd with less than 2.0 per cent of reactors to the last previous annual or semi-annual test, they shall be kept segregated from the herd until they pass a second satisfactory examination and test 60 to 90 days later. All tests shall be made by a veterinarian approved by the Commission and shall be applied in accordance with the technic approved by the U. S. Bureau of Animal Industry or the State Livestock Sanitary authorities.

30. Alternate Method for State and Federal Control.—All herds producing Certified milk not tested according to the requirements laid down in paragraphs 28 and 29 shall operate under the accredited herd plan for the control and eradication of bovine tuberculosis and tests shall be conducted accordingly, provided that all additions to the herd shall be tuberculin tested at the time of purchase unless such animals originate from fully accredited herds. All additions shall be kept segregated from the herd until they pass a satisfactory re-test 60 or 90 days after previous tests. In case additions are made to the herd, tuberculin tests shall be applied to the entire herd every six months.

The dates of all herd tests shall be definitely arranged by agreement between the Milk Commission and supervising officials and a complete record of all tests shall be made by the veterinarian making

the same and promptly reported by him to the Secretary of the Commission. These records shall be kept on file and a summary of all such tests shall be made available to the American Association of Medical Milk Commissions for statistical purposes.

31. Removal of Reactors.—All reactors shall be removed from the herd immediately after discovery and the milk shall be discarded, and the stables and exercise yards used by them shall be cleaned and disinfected in a manner approved by the Commission.

32. Control of Brucella Infections.—It is required that elimination of Bang abortion disease be actively prosecuted to the end that this disease be eradicated as early as possible from Certified herds.

a. No animal shall be used in the production of Certified Milk that shows positive evidence of infection with Brucella organisms.

b. Herds shall be under the supervision of such agencies as shall be acceptable to the State Live Stock Sanitary Authorities and to the local Milk Commission.

33. Identification of Cows.—Each dairy cow in each certified herd shall be ear-tagged or ear-marked with a number which will permanently identify her. Provision shall be made for the replacement of lost ear-tags.

34. Herd Record.—Each cow in the herd shall be registered in a herd record, which record shall be accurately kept so that her entrance and departure from the herd and her tuberculin testing can be identified. This record may contain other information useful to the owner or manager. This record shall be accessible to the Milk Commission or its representative and the producer shall be responsible for its accuracy.

35. Disposition of Cows Sick with Diseases Other than Tuberculosis.—No cow known or suspected to be diseased shall be permitted to remain in the milking herd. Any cow showing signs of disease, or under suspicion of being diseased, shall be immediately removed from the milking stable to a separate compartment or building provided for such animals and the milk shall not be used. Any cow affected with mastitis (garget) shall be removed from the milking herd, even if only one quarter of the udder is affected, and none of the milk from any of the quarters shall be used. No cow separated on account of disease shall be returned to the milking herd without the approval of the veterinarian.

36. Milking and Calving Period.—Milk from all cows shall be excluded for a period of 45 days before and 7 days after parturition. Cows shall not be permitted to calve in the milking stable and shall not be returned to said stable while the uterine discharges are putrid or purulent and under no condition before the seventh day following parturition.

37. Notification of Veterinary Inspector.—In the event of the occurrence of a disease which appears to be of a serious character between the visits of the veterinarian, or if a number of cows become sick at about the same time, it shall be the duty of the dairyman to withdraw such sickened cattle from the herd, to destroy their milk, and to notify the veterinary inspector by telegraph or telephone immediately.

38. Inspections.—A veterinary inspection of the health of the herd shall be made at intervals of not more than one month. Each cow in milk shall be subjected to a careful physical examination at least once each month, giving special attention to the udder and external genitals.

EMPLOYEES

39. Washing of Hands.—Adequate and conveniently located facilities shall be provided for the milkers. The hands of the milkers shall be thoroughly washed and scrubbed, using soap (preferably liquid), warm water and brush, and carefully dried on a clean towel immediately before milking. When hand milking is employed, the hands of the milkers shall be rinsed with clean running water and carefully dried before milking each cow. The practice of moistening the hands with milk is forbidden.

40. Employees' Clothing.—Milkers and other persons handling the milk shall wear clean white suits and caps that shall be worn for no other purpose. They shall use not less than three freshly laundered suits and caps each week, and these when not in use shall be kept in a clean place, protected from dust and dirt.

41.—Things to be Avoided by Milkers.—While engaged about the dairy or in handling the milk, employees shall not use tobacco or intoxicating liquors. They shall keep their fingers away from nose and mouth, and no milker shall permit his hands, fingers, or mouth to come in contact with milk intended for sale. During milking, the milkers shall be careful not to touch anything but the clean top of the milking stool, the milk pail and the cow's teats. Milkers are forbidden to spit upon the floors and walls of the stables, or upon the floor and walls of the milk house, or into the water used for cooling or cleansing purposes. These precautions are necessary to avoid the possibility of any disease-producing bacteria getting into the milk.

42. Toilet Rooms.—Toilet facilities for the milkers and others handling milk shall be provided and unless of the sanitary flush type shall be located outside of the stable or milk house. Flush closets shall not be in proximity to the bottling room or receiving room. All toilets shall be properly screened, shall be kept clean, and shall be accessible to wash basins, water, nail brush, soap and clean individual towels. Employees shall be required to wash and dry their hands immediately after leaving the toilet room. Sanitary drinking fountains or individual drinking cups for the employees should be installed in convenient locations both in the stables and dairy houses.

MILKING, HANDLING, TRANSPORTATION

43. Fore Milk.—The first streams from each teat shall be rejected. Such milk shall be milked through a very fine meshed strainer to help to determine the presence or absence of garget and be collected in a separate vessel and shall not be milked upon the floors or into the gutters. If milk from any cow is bloody, stringy, or in anywise unnatural, the milk from that cow shall be rejected and the cow shall be removed from the milking herd and shall not be returned until approved by the veterinarian. (See paragraph 35.) If dirt gets into the pail,

the milk shall be discarded and the pail washed and sterilized before it is used again. The pails shall be protected from extraneous contamination. The milking shall be done rapidly and quietly and the cows shall be treated kindly. Promptly after the milk is drawn it shall be removed from the stable and strained through strainers made of double layers of finely meshed cheesecloth or absorbent cotton or other approved material, thoroughly sterilized. Several strainers shall be provided for each milking in order that they may be frequently changed.

44. Temperature of Milk.—Proper cooling to reduce the temperature below 50° F. shall be used. Coolers shall be so situated that they can be protected from flies, dust, and odors. The milk shall be cooled immediately after being milked, and maintained at a temperature above freezing and below 50° F. until delivered to the consumer.

45. Capping and Sealing Bottles.—Certified Milk is to be bottled and sealed upon the farm where it is produced. Milk, after being cooled and bottled, shall be immediately capped and sealed in a manner satisfactory to the Commission. The inner cap shall be applied only by a suitable capping machine. The seal shall include a sterile hood which completely covers the lip of the bottle which cannot be used a second time for sealing the bottle and shall be marked on the exposed surface with the approved copyrighted design and color of the American Association of Medical Milk Commissions, Inc., the name of the Commission, the name of the farm and such other information as state or local health authorities may require. Certified Milk may be transported and delivered in cans properly sealed and marked, to hospitals and other institutions under Medical supervision.

46. Transportation.—In transit the milk packages shall be kept reasonably free from dust and dirt. The wagons, trays, and crates shall be kept clean.

47. Delivery Limit.—The milkings of any consecutive twenty-four-hour period shall constitute a day's product. Certified milk shall be delivered to the consumer in the shortest possible time after production as determined by each individual Milk Commission with a time limit of thirty hours from the time of the latest milking

DISTRIBUTORS

48. New or Clean Bottles.—Distributors must furnish a sufficient number of new or clean washed bottles to cover all shipments of Certified milk, unless local conditions make it more desirable that bottles be furnished by the producer.

49. Covered Boxes.—Distributors must furnish covered boxes for shipping Certified milk, unless local conditions make it more desirable that boxes be furnished by the producer.

50. Contaminated Bottles.—No bottles shall be collected from a house in which communicable disease exists except under conditions prescribed by the Health authorities.

51. Temperature.—Distributors handling Certified Milk must keep it at a temperature above the freezing point and below 50° F. from the time it is received until delivered to the consumer. This means that bottles shall be well packed in ice in warm weather, and not allowed to freeze in cold weather.

METHODS AND REGULATIONS FOR THE MEDICAL EXAMINATION OF EMPLOYEES, THEIR HEALTH AND PERSONAL HYGIENE

52. Medical Officer.—A medical officer, known as the attending dairy physician, shall be selected by the Commission, who should reside near the dairy producing Certified Milk. He shall be a physician in good standing and authorized by law to practice medicine; he shall be responsible to the Commission and subject to its direction. In case more than one dairy is under the control of the Commission and they are in different localities, a separate physician should be designated for the supervision of each dairy.

53. New Employees.—Every new employee for milking or handling milk or to be regularly employed on the farm shall be examined by the Medical Examiner before assuming his duties, except in cases of most extreme emergency, and all necessary laboratory tests shall be made when such are indicated. Health certificate covering each new employee shall be kept on file at the farm. Throat and nasal cultures of all new employees shall be made according to approved methods.

54. Protection against Enteric Fevers as a Group.—Each employee before assuming duties in which there may be any possibility of contaminating the milk shall have the following examinations:

a. History of enteric fevers.
b. Urine and feces cultures for organisms of typhoid, paratyphoid, and the dysenteries.
c. Widal agglutination tests.

If these examinations disclose no reasons to the contrary, the employee may be allowed to work.

It is the duty of the attending physician to have cultural examinations of feces and urine made whenever there is any clinical indication of enteric disease and to see that fresh and reliable specimens are furnished to the laboratory.

At the expiration of six months each old employee shall have repeated the feces and urine cultures specified above.

These examinations shall be conducted by laboratories and physicians appointed and approved by the Commission. Complete records shall be kept and filed with the Commission.

55. Medical Inspection.—The physician shall visit the farm, dormitories and boarding house weekly and examine all those who milk or handle the milk, and all the regular farm employees and shall report to the Milk Commission upon blank forms supplied for that purpose. This report shall be countersigned by the farm owner and a copy shall be kept on file at the farm for one year. The attending physician must make a complete examination of all employees at least once a year and a certificate or copy of it kept on file at the farm.

56. Medical Examination.—No person suffering with any communicable disease, and no person recently exposed to such disease shall be employed in the production of Certified Milk. No person known to be a typhoid carrier shall be employed on a certified farm. No person known, or suspected, to have had typhoid fever shall be employed except by special permit of the Milk Commission. In the event of any illness likely to prove dangerous to the milk, the patient shall be

immediately removed from the farm or properly isolated and the Milk Commission notified. Satisfactory evidence of successful vaccination against small pox within seven years shall be presented before employment. In case of an epidemic at or near a farm all employees shall be vaccinated.

57. Record of Employees.—A record shall be kept on the dairy premises of each employee which shall show his name and address, date of employment, his medical history, results of physical examination by physician, and the results of any examinations of cultures and other laboratory tests.

The physician shall check this record against the time book or time record.

58. Dormitories.—When employees live upon the premises their dormitories shall be constructed and operated according to plans approved by the Commission. Sufficient and modern bathing and toilet facilities shall be provided for all dairy employees.

STANDARDS

59. Certified Milk.—Certified Milk must be pure, clean, fresh, wholesome cow's milk in its natural state, not having been heated and without the addition of coloring matter or preservatives. Nothing must be added to the milk, and nothing taken away.

Milk which has been pasteurized shall not be sold under the copyrighted design and color of the American Association of Medical Milk Commissions—Incorporated.

60. Examinations.—Examinations of milk are to be made with frequency and at the option of the Milk Commission according to the season and condition of the milk, and at least once a week. All samples required for examination shall be furnished by the Distributors and collected at the discretion of the Milk Commission. Reports upon examinations should be sent to the Producers and Distributors.

61. Collection of Samples.—The samples to be examined shall be obtained from milk as offered for sale. The samples shall be received in the original packages, in properly iced containers, and they shall be so kept until examined, so as to limit as far as possible changes in their bacterial content.

62. Bacterial Counts.—Certified Milk shall contain not over 10,000 bacteria per cubic centimeter. In case a count exceeding 10,000 bacteria per cubic centimeter is found, daily counts shall be made and if normal counts are not restored within 10 days the certification may be suspended. Bacterial examinations shall be made as soon as possible after collection and in no case shall the interval be over four hours. Immediately after the plates have been prepared the temperature may be taken.

63. Bacterial Examinations.—The methods and technique used in the bacteriological examinations of Certified Milk shall conform to the standard methods and technique of the American Public Health Association for bacteriological examinations of milk.

It is recommended that samples of Certified Milk be examined at frequent intervals for the presence of *Streptococcus epidemicus* (Davis), and the *B. coli* group, according to the methods outlined below.

It is recommended that each cow should have her milk cultured before addition to the Certified herd for the presence of *Streptococcus epidermicus* and *B. coli.*

Examination for Streptococcus Epidemicus (Davis).—Samples of milk should be from individual cows, groups of about ten cows, or from the bottled milk. The examination should be made at least once a month. These samples should be diluted 1 to 20 with sterile Isotonic salt solution and plated in blood agar. The agar should be made from veal and should have a *p*H about 7.4. It should be used in measured amounts of 10 cc. to which 0.7 cc. of defibrinated horse blood should be added. The lower half of the Petri dishes should be 10 cm. in diameter in order to give a film of definite thickness. The temperature of incubation should be 37 degrees C. These plates should be examined at the end of 24 and 48 hours for colonies of *Streptococcus epidemicus* (Davis). Colonies of this streptococcus have the following characters: After 18 to 24 hours of incubation, they appear as typical beta colonies with a wide area of hemolysis. The colonies proper are very large for streptococci. The deep colonies average from 0.7 to 0.8 mm. in diameter and are dense. They are surrounded by a clear area that varies in average diameter from 2.5 to 3.00 mm. After 48 hours' incubation the colonies are larger, that is, 1 to 1.1 mm. and the hemolytic areas especially so, i.e., from 4.3 to 4.8 mm. The surface colonies which ordinarily are not of much significance in streptococcus work are in this organism quite characteristic. They are large, spreading and moist. Capsules should be sought for by the moist India ink method in material from young moist surface colonies. Conspicuous colonies should be picked into veal broth with a *p*H of 7.4 to which has been added aseptically two drops of horse or rabbit blood serum and incubated 8 to 12 hours. A gram stain should be made from the broth. Should a capsulated streptococcus be found it is probably *Streptococcus epidemicus.* If found in the milk of a single cow she should be removed from the herd immediately. If this organism is found in a group sample, then the individual animals contributing to the sample should have their milk examined, and if found in bottled milk then individual cows of the whole herd must be examined to find the offending cow, or cows.

The method given above is in the most abbreviated form. In order to definitely identify this organism it should be shown that in addition to the above characteristics, it has the power to hemolize in the test tubes; to ferment lactose, saccharose and salicin, but not mannite; to be a low acid former in glucose broth, *p*H usually from 4.8 to 5.4; and not to hydrolize sodium hippurate.

References.—Brown, Frost and Shaw: Hemolytic Streptococci of the beta type in Certified Milk. Jour. Inf. Dis. Vol. 38, May 1926, pp. 381-388.

Frost, Gumm and Thomas: Types of hemolytic streptococci in Certified Milk, Jour. Inf. Dis. Vol. 40, June 1927, pp. 698-705.

Method for Determining the Numbers of B. coli and B. lactis aerogenes in Certified Milk.—Certified milk in 0.1 cc. amounts should not contain these organisms. Because of the low total bacterial count of Certified Milk the following method has been found to give accurate results since the plates are not overcrowded with other organisms.

1. Inoculate 0.1 cc. of milk into lactose taurocholate agar (pour plate). Incubate 24 hours. Colonies of *B. coli* and *B. lactis acrogencs* are yellow.

2. If it is desired to differentiate *B. coli* from *B. lactis aerogenes*, colonies from the lactose taurocholate agar should be fished to the surface of citrate agar. This

medium should not be streaked with the colonies fished but should be spotted in well-isolated spots. *B. coli* should show little or no growth. *B. lactis aerogenes* should produce alkaline opaque colonies after incubation for 24 to 48 hours at 37° C.

Gram stains should be made to make sure that the organisms fished are Gram negative bacilli. Confirmatory tests in lactose broth fermentation tubes for gas and acid production and in glucose broth for Voges-Proskauer reaction may be employed if desired but it is believed that with a little experience the above procedures can be relied upon.

Media.—Lactose Taurocholate Agar (Chalmers, C. H., 1928, Jour. of Hygiene, xxvii, 295)

	gm. or cc.
Water	1000
Sodium taurocholate	5
Peptone	20
Lactose	10
Agar	20

Adjust reaction to *p*H 6.8 filter and add 0.006 per cent of brom cresol purple.

Citrate Agar (Simmons J. S., 1926 Jour. of Infectious Diseases, xxxix, 209)

	gm. or cc.
Distilled water	1000
Agar, clean and dry	20
NaCl	5
$MgSO_4$	0.2
$(NH_4)H_2PO_4$	1
K_2HPO_4	1
Sodium citrate	2

Adjust the reaction to *p*H 6.8 and add 10 cc. of 1.5% alcoholic solution of brom thymol blue.

64. Determination of Taste and Odor of Milk.—Immediately after the plates have been prepared, the taste and odor of the milk shall be determined. Chemical examinations may be made on samples previously examined for bacteria.

65. Chemical Analyses.—The methods and technique used in the chemical analyses shall conform to the methods and technique of the American Association of Official Agricultural Chemists.

66. Fat Standards.—Certified Milk shall contain an average of 4.0 per cent of butterfat with a minimum of 3.5 per cent. This average to be based on a period of not over 90 days.

67. Over or under Fat Standard.—In case it is desired to maintain an average butterfat per cent above or below the standard, the per cent of butterfat shall be stated on the seal of the container. Such average shall be based on tests covering a period of 90 days or less.

68. Cream Standard.—The percentage of butterfat in Certified Cream shall either be stated on the cap or confrom to legal standards.

All specifications covering Certified Milk except those referring to butterfat, shall also apply to Certified Cream.

LABORATORY EQUIPMENT FOR MILK ANALYSIS IN THE AVERAGE SMALL CITY

Chemical Apparatus:

1 Analytical balance with weights—1 milligram to 100 grams.
1 Cream-test scale.
1 Balance with weights to 5 kilos.
1 Westphal balance or accurate lactometer with cylinder.
1 Babcock milk-fat tester—12 bottles.
3 Dozen milk-test bottles, 8 per cent.
1 Dozen cream-test bottles, 9 grams, 50 per cent.
1 Thermometer, range—19 to 200° C.
1 Thermometer, range—10 to 110° C.
1 Thermometer, range— 0 to 212° F.
1 Water bath for milk solids, 12 holes.
1 Drying oven, double wall.
1 Wash bottle, 1 liter.
2 Pipettes, 17.6 c.c.
1 Pair dividers.
1 Combined acid bottle and pipette.
2 Burettes, 50 c.c. graduated in tenths.
1 Burette holder.
2 Dozen beakers, lipped—assorted sizes (100 to 250 c.c.).
12 Porcelain dishes, flat-bottomed.
2 Beakers, lipped—500 c.c.
2 Beakers, lipped—1000 c.c.
2 Iron supports, with sets of 4 rings, Nos. 2 to 4.
1 Desiccator.
1 Refractometer.
1 Sediment tester and 1000 cotton disks.
1 Dozen glass stirring rods.
1 Pipette, 5 c.c.
1 Pipette, 10 c.c.
1 Pipette, 25 c.c.
1 Pipette, 50 c.c.
2 Iron tripods.
25 Lengths, 2 meters each, glass tubing, assorted sizes, 2–4 mm.
6 Wire gauze, asbestos center.
1 Pair crucible tongs.
6 Bunsen burners.
24 Feet rubber tubing, thick wall, cloth wrapped $\frac{1}{4}$ inch.

6 Funnels glass, diameter 8 cm.
1 Pack filter paper—12.5 cm. diam., for qualitative analysis.
1 Pack filter paper—25 cm. diam. for qualitative analysis.
1 Funnel, 6 in.
12 Reagent bottles.
4 Test-tube cleaning brushes.

Bacteriological apparatus:

1 Microscope with accessories.
6 Inches platinum wire.
1 Water bath for melting agar tubes.
1 Autoclave with burner.
1 Arnold sterilizer.
1 Dry air sterilizing oven.
1 Incubator.
100 One c.c. pipettes graduated in tenths with extra tenth above 0 mark, to deliver between two marks.
200 Test-tubes, lipless, heavy wall to withstand sterilization.
4 Test-tube baskets.
Pipettes—5 c.c. to 50 c.c. (See chemical list.)
1 Cylinder, 1000 c.c. graduated.
1 Cylinder, 100 c.c. graduated.
2 Dozen Erlenmeyer flasks, 300 c.c.
6 Erlenmyer flasks, 1000 c.c.
4 Dozen glass bottles, glass-stoppered, 6 ounces.
1 Double boiler, granite ware, $\frac{1}{2}$ gallon.
200 Petri dishes 100×10 mm.
2 Petri-dish boxes, sheet iron, 50 each.
2 Pipette boxes.
1 Reading glass—4 in., $2\frac{1}{2}$ magnifications.
1 Counting plate.
1 Counter.
1 Gas stove, single burner.
Burners and tubing. (See chemical list.)
2 Wax pencils.

Chemical Reagents and Solutions:

Commercial sulphuric acid; sulphuric acid C. P.
Hydrochloric acid, C. P.
Nitric acid, C. P.
Sodium hydroxide, normal.
Sodium hydroxide, tenth normal.

Hydrochloric acid, normal.
Hydrochloric acid, tenth normal phenolphthalein indicator
Calcium chloride.
Acetic acid, glacial.
Potassium bichromate.
Peptone.
Beef extract.
Agar, shredded.
Absorbent and non-absorbent cotton.
Microscopical stains.
Grams (set of reagents) methylene blue
Stronger ammonia water.
Borax or boric acid.
Ether.
Ferric chloride, crystals.
Litmus paper, red and blue.
Turmeric paper.
Alcohol, 95 per cent.
Phenol, pure crystals.

WHOLESALE MILK PRICES, NEW YORK, QUART.*

Year.	Jan. Cents.	Feb. Cents.	March. Cents.	April. Cents.	May. Cents.	June. Cents.	July. Cents.	Aug. Cents.	Sept. Cents.	Oct. Cents.	Nov. Cents.	Dec. Cents.
1899	2.75	2.50	2.50	2.25	2.12	2.00	2.17	2.25	2.50	2.85	3.25	3.25
1900	3.00	3.00	2. 5	2.50	2.29	2.25	2.44	2.63	2.75	3.00	3.00	3.25
1901	3.00	2.75	2.63	2.50	2.12	2.00	2.25	2.36	2.50	2.75	3.08	3.50
1902	3.38	3.25	3.04	2.87	2.63	2.25	2.25	2.42	2.50	3.00	3.25	3.75
1903	3.50	3.50	3.31	3.12	2.65	2.36	2.25	2.25	2.58	2.84	3.00	3.25
1904	3.12	3.00	3.00	2.75	2.37	2.00	2.09	2.25	2.50	2.88	3.32	3.75
1905	3.50	3.38	3.12	2.83	2.56	2.00	2.38	2.50	2.75	3.00	3.17	3.50
1906	3.50	3.43	3.12	2.87	2.58	2.25	2.34	2.66	2.90	3.25	3.50	3.75
1907	3.75	3.50	3.25	3.25	2.87	2.50	2.63	3.09	3.38	4.00	4.00	4.00
1908	4.00	3.75	3.50	3.12	2.62	2.25	2.50	3.00	3.13	3.75	3.83	4.00
1909	3.91	3.63	3.50	3.12	2.67	2.25	2.75	3.13	3.50	3.75	4.05	4.25
1910	4.12	4.00	3.75	3.58	3.00	3.00	3.26	3.50	3.67	4.00	4.00	4.25
1911	3.91	3.75	3.25	2.88	2.75	2.50	2.85	3.13	3.25	3.75	4.09	4.25
1912	4.25	4.13	3.75	3.50	3.25	3.00	3.26	3.50	3.50	3.75	4.00	4.25
1913	3.75	3.75	3.50	3.33	3.00	2.75	3.00	3.50	3.75	4.00	4.04	4.04
1914	4.00	3.75	3.50	3.25	2.66	2.75	3.00	3.25	3.50	4.00	4.25	4.25
1915	4.13	3.93	3.75	3.25	2.75	2.75	3.00	3.25	3.50	3.75	4.25	4.25
1916	4.12	4.00	3.75	3.25	3.00	2.75	3.13	3.50	3.65	5.00	5.23	5.22
1917	5.12	5.00	4.90	4.88	4.77	4.55	4.97	5.95	5.95	7.17	7.70	7.17
1918	8.08	7.70	7.45	5.90	5.82	4.42	5.38	6.32	6.75	8.17	8.70	9.23
1919	9.13	8.12	7.63	6.62	7.20	6.83	7.07	7.33	7.50	7.30	7.75	8.50
1920	7.33	6.94	6.75	5.24	5.24							

"Price reduced to quart basis as reported in various issues of Milk Reporter and by letter from publishers, Milk Exchange prices prior to 1916, Dairymen's League schedule since 1916. Early prices net to producer at country stations having a freight rate of 26 cents per 40-quart can. Recent prices net to producer at 151 to 160 mile zone. Calculated to 3.7 per cent fat when fat was recognized in prices, New York prices are now quoted regularly for 3.0 per cent milk at the 200 to 210 mile zone."

* From "The Marketing of Whole Milk," by H. E. Erdman, published by Macmillan Company, New York, 1921.

For Determining Total Solids in Milk from any Given Specific Gravity and Percentage of Fat

(Per Cent of Total Solids)

Percentage of Fat.	Lactometer Reading at 60° F. (Quevenne Degrees).										
	26	27	28	29	30	31	32	33	34	35	36
2.00	8.90	9.15	9.40	9.65	9.90	10.15	10.40	10.66	10.91	11.16	11.41
2.05	8.96	9.21	9.46	9.71	9.96	10.21	10.46	10.72	10.97	11.22	11.47
2.10	9.02	9.27	9.52	9.77	10.02	10.27	10.52	10.78	11.03	11.28	11.53
2.15	9.08	9.33	9.58	9.83	10.08	10.33	10.58	10.84	11.09	11.34	11.59
2.20	9.14	9.39	9.64	9.89	10.14	10.39	10.64	10.90	11.15	11.40	11.65
2.25	9.20	9.45	9.70	9.95	10.20	10.45	10.70	10.96	11.21	11.46	11.71
2.30	9.26	9.51	9.76	10.01	10.26	10.51	10.76	11.02	11.27	11.52	11.77
2.35	9.32	9.57	9.82	10.07	10.32	10.57	10.82	11.08	11.33	11.58	11.83
2.40	9.38	9.63	9.88	10.13	10.38	10.63	10.88	11.14	11.39	11.64	11.89
2.45	9.44	9.69	9.94	10.19	10.44	10.69	10.94	11.20	11.45	11.70	11.95
2.50	9.50	9.75	10.00	10.25	10.50	10.75	11.00	11.26	11.51	11.76	12.01
2.55	9.56	9.81	10.06	10.31	10.56	10.81	11.06	11.32	11.57	11.82	12.07
2.60	9.62	9.87	10.12	10.37	10.62	10.87	11.12	11.38	11.63	11.88	12.13
2.65	9.68	9.93	10.18	10.43	10.68	10.93	11.18	11.44	11.69	11.94	12.19
2.70	9.74	9.99	10.24	10.49	10.74	10.99	11.24	11.50	11.75	12.00	12.25
2.75	9.80	10.05	10.30	10.55	10.80	11.05	11.31	11.56	11.81	12.06	12.31
2.80	9.86	10.11	10.36	10.61	10.86	11.11	11.37	11.62	11.87	12.12	12.37
2.85	9.92	10.17	10.42	10.67	10.92	11.17	11.43	11.68	11.93	12.18	12.43
2.90	9.98	10.23	10.48	10.73	10.98	11.23	11.49	11.74	11.99	12.24	12.49
2.95	10.04	10.29	10.54	10.79	11.04	11.30	11.55	11.80	12.05	12.30	12.55
3.00	10.10	10.35	10.60	10.85	11.10	11.36	11.61	11.86	12.11	12.36	12.61
3.05	10.16	10.41	10.66	10.91	11.17	11.42	11.67	11.92	12.17	12.42	12.68
3.10	10.22	10.47	10.72	10.97	11.23	11.48	11.73	11.98	12.23	12.48	12.74
3.15	10.28	10.53	10.78	11.03	11.29	11.54	11.79	12.04	12.29	12.55	12.80
3.20	10.34	10.59	10.84	11.09	11.35	11.60	11.85	12.10	12.35	12.61	12.86
3.25	10.40	10.65	10.90	11.16	11.41	11.66	11.91	12.16	12.42	12.67	12.92
3.30	10.46	10.71	10.96	11.22	11.47	11.72	11.97	12.22	12.48	12.73	12.98
3.35	10.52	10.77	11.03	11.28	11.53	11.78	12.03	12.28	12.54	12.79	13.04
3.40	10.58	10.83	11.09	11.34	11.59	11.84	12.09	12.34	12.60	12.85	13.10
3.45	10.64	10.89	11.15	11.40	11.65	11.90	12.15	12.40	12.66	12.91	13.16
3.50	10.70	10.95	11.21	11.46	11.71	11.96	12.21	12.46	12.72	12.97	13.22
3.55	10.76	11.02	11.27	11.52	11.77	12.02	12.27	12.52	12.78	13.03	13.28
3.60	10.82	11.08	11.33	11.58	11.83	12.08	12.33	12.58	12.84	13.09	13.34
3.65	10.88	11.14	11.39	11.64	11.89	12.14	12.39	12.64	12.90	13.15	13.40
3.70	10.94	11.20	11.45	11.70	11.95	12.20	12.45	12.70	12.96	13.21	13.46
3.75	11.00	11.26	11.51	11.76	12.01	12.26	12.51	12.76	13.02	13.27	13.52
3.80	11.06	11.32	11.57	11.82	12.07	12.32	12.57	12.82	13.08	13.33	13.58
3.85	11.12	11.38	11.63	11.88	12.13	12.38	12.63	12.88	13.14	13.39	13.64
3.90	11.18	11.44	11.69	11.94	12.19	12.44	12.69	12.94	13.20	13.45	13.70
3.95	11.24	11.50	11.75	12.00	12.25	12.50	12.75	13.00	13.26	13.51	13.77
4.00	11.30	11.56	11.81	12.06	12.31	12.56	12.81	13.06	13.32	13.57	13.83
4.05	11.36	11.62	11.87	12.12	12.37	12.62	12.87	13.12	13.38	13.63	13.89
4.10	11.42	11.68	11.93	12.18	12.43	12.68	12.93	13.18	13.44	13.69	13.95
4.15	11.48	11.74	11.99	12.24	12.49	12.74	12.99	13.25	13.50	13.76	14.01
4.20	11.54	11.80	12.05	12.30	12.55	12.80	13.05	13.31	13.56	13.82	14.07

FOR DETERMINING TOTAL SOLIDS IN MILK FROM ANY GIVEN SPECIFIC GRAVITY AND PERCENTAGE OF FAT.—*Continued*

(Per Cent Total Solids)

Percentage of Fat.	Lactometer Reading at 60° F. (Quevenne Degrees.)										
	26	27	28	29	30	31	32	33	34	35	36
4.25	11.60	11.86	12.11	12.36	12.61	12.86	13.12	13.37	13.62	13.88	14.13
4.30	11.66	11.92	12.17	12.42	12.67	12.92	13.18	13.43	13.68	13.94	14.19
4.35	11.72	11.98	12.23	12.48	12.73	12.98	13.24	13.49	13.74	14.00	14.25
4.40	11.78	12.04	12.29	12.54	12.79	13.04	13.30	13.55	13.80	14.06	14.31
4.45	11.84	12.10	12.35	12.60	12.85	13.10	13.36	13.61	13.86	14.12	14.37
4.50	11.90	12.16	12.41	12.66	12.91	13.16	13.42	13.67	13.92	14.18	14.43
4.55	11.97	12.22	12.47	12.72	12.97	13.22	13.48	13.73	13.98	14.24	14.49
4.60	12.03	12.28	12.53	12.78	13.03	13.28	13.54	13.79	14.04	14.30	14.55
4.65	12.09	12.34	12.59	12.84	13.09	13.34	13.60	13.85	14.10	14.36	14.61
4.70	12.15	12.40	12.65	12.90	13.15	13.40	13.66	13.91	14.16	14.42	14.67
4.75	12.21	12.46	12.71	12.96	13.21	13.46	13.72	13.97	14.22	14.48	14.73
4.80	12.27	12.52	12.77	13.02	13.27	13.52	13.78	14.03	14.28	14.54	14.79
4.85	12.33	12.58	12.83	13.08	13.33	13.58	13.84	14.09	14.34	14.60	14.85
4.90	12.39	12.64	12.89	13.14	13.39	13.64	13.90	14.15	14.40	14.66	14.91
4.95	12.45	12.70	12.95	13.20	13.45	13.70	13.96	14.21	14.46	14.72	14.97
5.00	12.51	12.76	13.01	13.26	13.51	13.76	14.02	14.27	14.52	14.78	15.03
5.05	12.57	12.82	13.07	13.32	13.57	13.83	14.08	14.33	14.58	14.84	15.09
5.10	12.63	12.88	13.13	13.38	13.63	13.89	14.14	14.39	14.64	14.90	15.15
5.15	12.69	12.94	13.19	13.44	13.69	13.95	14.20	14.45	14.70	14.96	15.21
5.20	12.75	13.00	13.25	13.50	13.75	14.01	14.26	14.51	14.76	15.02	15.27
5.25	12.81	13.06	13.31	13.56	13.81	14.07	14.32	14.57	14.82	15.08	15.33
5.30	12.87	13.12	13.37	13.62	13.87	14.13	14.38	14.63	14.88	15.14	15.39
5.35	12.93	13.18	13.43	13.68	13.93	14.19	14.44	14.70	14.95	15.20	15.45
5.40	12.99	13.24	13.49	13.74	14.00	14.25	14.50	14.76	15.01	15.26	15.51
5.45	13.05	13.30	13.55	13.80	14.06	14.31	14.56	14.82	15.07	15.32	15.57
5.50	13.11	13.36	13.61	13.86	14.12	14.37	14.62	14.88	15.13	15.38	15.63
5.55	13.17	13.42	13.67	13.93	14.18	14.43	14.69	14.94	15.19	15.44	15.69
5.60	13.23	13.48	13.73	13.99	14.24	14.49	14.75	15.00	16.25	15.50	15.75
5.65	13.29	13.54	13.79	14.05	14.30	14.55	14.81	15.06	15.31	15.56	15.81
5.70	13.35	13.60	13.85	14.11	14.36	14.61	14.87	15.12	15.37	15.62	15.87
5.75	13.41	13.66	13.91	14.17	14.42	14.68	14.93	15.18	15.43	15.68	15.93
5.80	13.47	13.72	13.97	14.23	14.48	14.74	14.99	15.24	15.49	15.74	15.99
5.85	13.53	13.78	14.04	14.29	14.54	14.80	15.05	15.30	15.55	15.80	16.06
5.90	13.59	13.84	14.10	14.35	14.60	14.86	15.11	15.36	15.61	15.86	16.12
5.95	13.65	13.90	14.16	14.41	14.66	14.92	15.17	15.42	15.67	15.92	16.18
6.00	13.71	13.96	14.22	14.47	14.72	14.98	15.23	15.48	15.73	15.98	16.24
6.05	13.77	14.02	14.28	14.53	14.78	15.04	15.29	15.54	15.79	16.04	16.30
6.10	13.83	14.08	14.34	14.59	14.84	15.10	15.35	15.60	15.85	16.10	16.35
6.15	13.89	14.14	14.40	14.65	14.90	15.16	15.41	15.66	15.91	16.16	16.42
6.20	13.95	14.20	14.46	14.71	14.96	15.22	15.47	15.72	15.97	16.22	16.48
6.25	14.01	14.26	14.52	14.77	15.02	15.28	15.53	15.78	16.03	16.28	16.54
6.30	14.07	14.32	14.58	14.83	15.08	15.34	15.59	15.84	16.09	16.34	16.60
6.35	14.13	14.38	14.64	14.90	15.14	15.40	15.65	15.90	16.15	16.40	16.66
6.40	14.19	14.44	14.70	14.96	15.20	15.46	15.71	15.96	16.21	16.46	16.72
6.45	14.25	14.50	14.76	15.02	15.26	15.52	15.77	16.02	16.27	16.52	16.78

Comparison of Fahrenheit and Centigrade Thermometer Scales

Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.
212	100.00	169	76.11	126	52.22	83	28.33	40	4.44
211	99.44	168	75.55	125	51.67	82	27.78	39	3.89
210	98.89	167	75.00	124	51.11	81	27.22	38	3.33
209	98.33	166	74.44	123	50.55	80	26.67	37	2.78
208	97.78	165	73.89	122	50.00	79	26.11	36	2.22
207	97.22	164	72.33	121	49.44	78	25.55	35	1.67
206	96.67	163	72.78	120	48.89	77	25.00	34	1.11
205	96.11	162	71.22	119	48.33	76	24.44	33	0.55
204	95.55	161	71.67	118	47.78	75	23.89	32	0.00
203	95.00	160	71.11	117	47.22	74	23.33	31	− 0.55
202	94.44	159	70.55	116	46.67	73	22.78	30	− 1.11
201	93.89	158	70.00	115	46.11	72	22.22	29	− 1.67
200	93.33	157	69.44	114	45.55	71	21.67	28	− 2.22
199	92.78	156	68.89	113	45.00	70	21.11	27	− 2.78
198	92.22	155	68.33	112	44.44	69	20.55	26	− 3.33
197	91.67	154	67.78	111	43.89	68	20.00	25	− 3.89
196	91.11	153	67.22	110	43.33	67	19.44	24	− 4.44
195	90.55	152	66.67	109	42.78	66	18.89	23	− 5.00
194	90.00	151	66.11	108	42.22	65	18.33	22	− 5.55
193	89.44	150	65.55	107	41.67	64	17.78	21	− 6.11
192	88.89	149	65.00	106	41.11	63	17.22	20	− 6.67
191	88.33	148	64.44	105	40.55	62	16.67	19	− 7.22
190	87.78	147	63.89	104	40.00	61	16.11	18	− 7.78
189	87.22	146	63.33	103	39.44	60	15.55	17	− 8.33
188	86.67	145	62.78	102	38.89	59	15.00	16	− 8.89
187	86.11	144	62.22	101	38.33	58	14.44	15	− 9.44
186	85.55	143	61.67	100	37.78	57	13.89	14	−10.00
185	85.00	142	61.11	99	37.22	56	13.33	13	−10.55
184	84.44	141	60.55	98	36.67	55	12.78	12	−11.11
183	83.89	140	60.00	97	36.11	54	12.22	11	−11.67
182	83.33	139	59.44	96	35.55	53	11.67	10	−12.22
181	82.78	138	58.89	95	35.00	52	11.11	9	−12.78
180	82.22	137	58.33	94	34.44	51	10.55	8	−13.33
179	81.67	136	57.78	93	33.89	50	10.00	7	−13.89
178	81.11	135	57.22	92	33.33	49	9.44	6	−14.44
177	80.55	134	56.67	91	32.78	48	8.89	5	−15.00
176	80.00	133	56.11	90	32.22	47	8.33	4	−15.55
175	79.44	132	55.55	89	31.67	46	7.78	3	−16.11
174	78.89	131	55.00	88	31.11	45	7.22	2	−16.67
173	78.33	130	54.44	87	30.55	44	6.67	1	−17.22
172	77.78	129	53.89	86	30.00	43	6.11	0	−17.78
171	77.22	128	53.33	85	29.44	42	5.55	−1	−18.33
170	76.67	127	52.78	84	28.89	41	5.00	−2	−18.89
								−3	−19.44

TABLE FOR CORRECTING THE LACTOMETER READING OF MILK ACCORDING TO TEMPERATURE

Degrees of Lactometer.	Degrees of Thermometer (F.).										
	45	46	47	48	49	50	51	52	53	54	55
20	19.0	19.0	19.1	19.1	19.2	19.2	19.3	19.4	19.4	19.5	19.6
21	19.9	20.0	20.0	20.1	20.2	20.3	20.3	20.3	20.4	20.5	20.6
22	20.9	21.0	21.0	21.1	21.2	21.2	21.3	21.3	21.4	21.5	21.6
23	21.9	22.0	22.0	22.1	22.2	22.2	22.3	22.3	22.4	22.5	22.6
24	22.9	22.9	23.0	23.1	23.2	23.2	23.3	23.3	23.4	23.5	23.6
25	23.8	23.9	24.0	24.0	24.1	24.1	24.2	24.3	24.4	24.5	24.6
26	24.8	24.9	24.9	25.0	25.1	25.1	25.2	25.2	25.3	25.4	25.5
27	25.8	25.9	25.9	26.0	26.1	26.1	26.2	26.2	26.3	26.4	26.5
28	26.7	26.8	26.8	26.9	27.0	27.0	27.1	27.2	27.3	27.4	27.5
29	27.7	27.8	27.8	27.9	28.0	28.0	28.1	28.2	28.3	28.4	28.5
30	28.6	28.7	28.7	28.8	28.9	29.0	29.1	29.1	29.2	29.3	29.4
31	29.5	29.6	29.6	29.7	29.8	29.9	30.0	30.1	30.2	30.3	30.4
32	30.4	30.5	30.5	30.6	30.7	30.9	31.0	31.1	31.2	31.3	31.4
33	31.3	31.4	31.4	31.5	31.6	31.8	31.9	32.0	32.1	32.3	32.4
34	32.2	32.3	32.3	32.4	32.5	32.7	32.9	33.0	33.1	33.2	33.3
35	33.0	33.1	33.2	33.4	33.5	33.6	33.8	33.9	34.0	34.2	34.3

	56	57	58	59	60	61	62	63	64	65
20	19.7	19.8	19.9	19.9	.....	20.1	20.2	20.2	20.3	20.4
21	20.7	20.8	20.9	20.9	.....	21.1	21.2	21.3	21.4	21.5
22	21.7	21.8	21.9	21.9	.....	22.1	22.2	22.3	22.4	22.5
23	22.7	22.8	22.8	22.9	.....	23.1	23.2	23.3	23.4	23.5
24	23.6	23.7	23.8	23.9	.....	24.1	24.2	24.3	24.4	24.5
25	24.6	24.7	24.8	24.9	.....	25.1	25.2	25.3	25.4	25.5
26	25.6	25.7	25.8	25.9	.....	26.1	26.2	26.3	26.5	26.6
27	26.6	26.7	26.8	26.9	.....	27.1	27.3	27.4	27.5	27.6
28	27.6	27.7	27.8	27.9	.....	28.1	28.3	28.4	28.5	28.6
29	28.6	28.7	28.8	28.9	.....	29.1	29.3	29.4	29.5	29.6
30	29.6	29.7	29.8	29.9	.....	30.1	30.3	30.4	30.5	30.7
31	30.5	30.6	30.8	30.9	.....	31.2	31.3	31.4	31.5	31.7
32	31.5	31.6	31.7	31.9	.....	32.2	32.3	32.5	32.6	32.7
33	32.5	32.6	32.7	32.9	.....	33.2	33.3	33.5	33.6	33.8
34	33.5	33.6	33.7	33.9	.....	34.2	34.3	34.5	34.6	34.8
35	34.5	34.6	34.7	34.9	.....	35.2	35.3	35.5	35.6	35.8

	66	67	68	69	70	71	72	73	74	75
20	20.5	20.6	20.7	20.9	21.0	21.1	21.2	21.3	21.5	21.6
21	21.6	21.7	21.8	22.0	22.1	22.2	22.3	22.4	22.5	22.6
22	22.6	22.7	22.8	23.0	23.1	23.2	23.3	23.4	23.5	23.7
23	23.6	23.7	23.8	24.0	24.1	24.2	24.3	24.4	24.6	24.7
24	24.6	24.7	24.9	25.0	25.1	25.2	25.3	25.5	25.6	25.7
25	25.6	25.7	25.9	26.0	26.1	26.2	26.4	26.5	26.6	26.8
26	26.7	26.8	27.0	27.1	27.2	27.3	27.4	27.5	27.7	27.8
27	27.7	27.8	28.0	28.1	28.2	28.3	28.4	28.6	28.7	28.9
28	28.7	28.8	29.0	29.1	29.2	29.4	29.5	29.7	29.8	29.9
29	29.8	29.9	30.1	30.2	30.3	30.4	30.5	30.7	30.9	31.0
30	30.8	30.9	31.1	31.2	31.3	31.5	31.6	31.8	31.9	32.1
31	31.7	31.8	32.0	32.2	32.4	32.5	32.6	32.8	33.0	33.1
32	32.9	33.0	33.2	33.3	33.4	33.6	33.7	33.9	34.0	34.2
33	33.9	34.0	34.2	34.3	34.5	34.6	34.7	34.9	35.1	35.2
34	34.9	35.0	35.2	35.3	35.5	35.6	35.8	36.0	36.1	36.3
35	35.9	36.1	36.2	36.4	36.5	36.7	36.8	37.0	37.2	37.3

Comparison of Metric and Customary Weights and Measures

Customary Weights and Measures.	Equivalents in Metric System.	Metric Weights and Measures.	Equivalents in Customary System.
1 inch	2.54 centimeters	1 meter	39.37 inches
1 foot	0.3048 meter	1 meter	1.0936 yards
1 square inch	6.452 square centimeters	1 square centimeter	0.155 square inch
1 square foot	9.29 square decimeters	1 square meter	10.764 square feet
1 cubic inch	16.387 cubic centimeters	1 cubic centimeter	0.061 cubic inch
1 cubic foot	0.0283 cubic meter	1 cubic centimeter	0.0338 fluid ounce
1 fluid ounce	29.57 cubic centimeters	1 cubic decimeter	61.023 cubic inches
1 quart	0.9464 liter	1 liter	1.0567 quarts
1 gallon	3.7854 liters	1 dekaliter	2.6417 gallons
1 grain	64.8 milligrams	1 gram	15.43 grains
1 ounce (av.)	28.35 grams	1 gram	0.035274 ounce
1 pound (av.)	0.4536 kilogram	1 kilogram	2.2046 pounds (av.)

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF DAIRY INDUSTRY

Washington, D. C.

Approximate Weight per Gallon of Milk and Cream at Various Temperatures

Degrees Fahr.	40	45	50	55	60	65	70	75	80	85	90
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Skim-milk	8.66	8.655	8.65	8.645	8.640	8.635	8.63	8.625	8.620	8.610	8.60
4% milk	8.61	8.605	8.60	8.595	8.590	8.585	8.58	8.570	8.565	8.560	8.55
20% cream	8.54	8.525	8.51	8.495	8.480	8.460	8.45	8.435	8.420	8.405	8.39
25% cream	8.50	8.485	8.47	8.450	8.435	8.420	8.40	8.385	8.370	8.355	8.34
30% cream	8.47	8.450	8.43	8.410	8.390	8.370	8.35	8.330	8.315	8.295	8.28
35% cream	8.45	8.425	8.40	8.375	8.350	8.330	8.31	8.290	8.270	8.250	8.23
40% cream	8.42	8.395	8.37	8.345	8.320	8.295	8.27	8.250	8.230	8.210	8.19

Degrees Fahr.	95	100	105	110	115	120	125	130	135	140	145
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Skim-milk	8.590	8.58	8.57	8.555	8.542	8.530	8.517	8.505	8.490	8.480	8.470
4% milk	8.535	8.52	8.51	8.500	8.485	8.475	8.465	8.450	8.440	8.430	8.420
20% cream	8.380	8.37	8.36	8.350	8.335	8.325	8.315	8.300	8.290	8.280	8.270
25% cream	8.325	8.31	8.30	8.290	8.280	8.270	8.260	8.250	8.240	8.230	8.220
30% cream	8.265	8.25	8.24	8.230	8.215	8.205	8.195	8.185	8.170	8.160	8.150
35% cream	8.215	8.20	8.19	8.175	8.165	8.155	8.145	8.130	8.120	8.110	8.100
40% cream	8.150	8.15	8.14	8.125	8.110	8.100	8.090	8.075	8.065	8.050	8.045

STATE STANDARDS FOR MILK AND CREAM IN EFFECT 1928

States	Milk			Skim Milk	Cream	Standards Established by
	Per Cent Total Solids	Per Cent Solids-not-fat	Per Cent Fat	Per Cent Total Solids	Per Cent Fat	
Alabama	11.75	8.5	3.25	.....	18	Law.
Alaska	.....	.....	.....	.....	.....	(No Territorial standards).
Arizona	11.95	8.7	3.25	.....	18	Act of Legislature and Regulations.
Arkansas	.....	.....	.....	.....	.....	(No State standards).
California	11.8	8.5	3.3	8.8	18	Act of Legislature.
Colorado	.....	.....	3	.....	16	Act of Legislature.
Connecticut	11.75	8.5	3.25	.....	16	Act of Legislature.
Delaware	11.75	8.5	3.25	.....	18	State Board of Health under legislative authority.
District of Columbia	11.5	8	3.5	9	20	Act of Congress.
Florida	.....	8.5	3.25	.....	18	Law.
Georgia	11.75	8.5	3.25	9.25	18	State Veterinarian under legislative authority.
Hawaii	11.5	8.5	3	.....	18	Act of Legislature and Food Department under legislative authority.
Idaho	11	8	3.2	9.3	18	Act of Legislature and by Public Welfare Department under legislative authority.
Illinois	11.5	8.5	3	9.25	18	Act of Legislature and Food Standard Commission under legislative authority.
Indiana	11.75	8.5	3.25	9.25	18	Act of Legislature and State Board of Health under legislative authority.
Iowa	11.5	8.5	3	*	16	Act of Legislature and Dairy and Food Commission under legislative authority.
Kansas	.....	.....	3.25	.....	18	State Board of Health under legislative authority.
Kentucky	.....	8.5	3.25	.....	18	State Board of Health under legislative authority.
Louisiana	.....	8.5	3.25	8	18	Act of Legislature and State Board of Health under legislative authority.
Maine	11.75	.....	3.25	.....	18	Act of Legislature.
Maryland	12.50	.....	3.50	.....	18	Legislative act provides for adoption of standards and definitions under U. S. Food and Drugs Act.
Massachusetts	12	.....	3.35	9.3	15	Act of Legislature and State Board of Health under legislative authority.
Michigan	12.5	.....	3	.....	18	Act of Legislature.
Minnesota	.....	.....	3.25	.....	20	Act of Legislature and State Dairy and Food Commission under legislative authority.
Mississippi	11.75	8.5	3.0	8.5	18	Law.
Missouri	.....	.....	.....	.....	.....	Same as Federal.
Montana	11.75	8.5	3.25	9.9	20	Act of Legislature and regulations or Dairy Commissioner under legislative authority.

* Less than 11.5 per cent total solids or 3.0 per cent fat.

STATE STANDARDS FOR MILK AND CREAM IN EFFECT 1928—*Continued*

States	Milk			Skim Milk	Cream	Standards Established by
	Per Cent Total Solids	Per Cent Solids-not-fat	Per Cent Fat	Per Cent Total Solids	Per Cent Fat	
Nebraska	.....	.....	3	9.25	.....	Act of Legislature and Food, Drug, Dairy and Oil Commission under legislative authority.
Nevada	11.75	8.5	3.25	.....	22	Regulation.
New Hampshire	11.85	.....	3.35	8.5	18	Act of Legislature and State Board of Health under legislative authority.
New Jersey	11.5	.....	3	.....	16	Act of Legislature and Food Department under legislative authority.
New Mexico	.....	.....	.....	.....	.....	No State standards.
New York	11.5	.....	3	8.5	18	Act of Legislature and Public Health Council under legislative authority.
North Carolina	.....	8.5	3.25	9.25	18	State Agriculture Department under legislative authority.
North Dakota	.....	8.5	3.25	.....	.....	Food Department under legislative authority.
Ohio	12	9	3‡	.....	18	Act of Legislature.
Oklahoma	12	8.5	3.5	.....	18	State Board of Agriculture under legislative authority.
Oregon	11.7	8.5	3.2	.....	18	Act of Legislature.
Pennsylvania	12	.....	3.25	.....	18	Act of Legislature.
Philippine Islands	11.75	8.5	3.25	.....	18	By Health Department under legislative authority.
Porto Rico	†	†	†	†	†	U. S. Food and Drugs Act and Board of Health under legislative authority.
Rhode Island	12	.....	3.25	.....	18 40	Food and Dairy Departments under legislative authority.
South Carolina	.....	.....	.....	.....	.....	
South Dakota	11.75	8.5	3.25	.....	18	Act of Legislature.
Tennessee	12	8.5	3.25	.....	.....	Act of Legislature.
Texas	.....	.....	.....	9.25	18	Food and Drug Department under legislative authority.
Utah	12	8.8	3.2	9	18 24 30	Act of Legislature.
Vermont	11.75	8.5	3.25	8.5	18	Act of Legislature and State Board of Health under legislative authority.
Virginia	11.75	8.5	3.25	9.25	18	Food Department under legislative authority.
Washington	.....	8.5	3.25	8.8	18	Act of Legislature.
West Virginia	11.5	8.5	3	9.0	18	Law.
Wisconsin	.....	8.5	3	9	18	Act of Legislature.
Wyoming	11.5	8.5	3	9.25	18	Dairy, Food and Oil Department under legislative authority.

† U. S. Dept. of Agriculture rulings.
‡ Standardized milk must contain at least 3.5 per cent fat.

New York Milk Receipts

(From New York Produce Review, Vol. 69, No. 13, p. 629, 1930)

	Cans Milk 40-qt. Each	Cans Cream and Condensed Milk	The Whole Equal to Plain Milk * Cans 40-qt.
1927			
January	2,653,906	114,240	3,668,360
February	2,475,473	118,410	3,523,951
March	2,830,004	160,323	4,231,228
April	2,719,026	181,627	4,281,021
May	2,863,221	240,322	4,896,334
June	2,902,809	268,064	5,114,337
July	2,996,804	246,122	4,945,626
August	2,767,362	194,951	4,348,413
September	2,789,560	170,491	4,466,140
October	2,874,531	142,869	4,123,209
November	2,713,410	121,878	3,787,157
December	2,706,795	123,059	3,799,562
Totals	33,262,901	2,082,356	51,185,338
Daily average	91,131	5,705	140,234
1928			
January	2,742,719	131,480	3,910,260
February	2,610,329	130,258	3,767,022
March	2,855,340	163,034	4,280,258
April	2,740,317	186,653	4,345,530
May	2,938,957	252,641	5,076,300
June	2,896,653	260,627	5,082,923
July	3,502,508	271,930	5,238,848
August	2,929,059	217,947	4,696,607
September	2,838,805	180,284	4,389,246
October	2,921,218	147,903	4,213,894
November	2,717,137	123,182	3,802,370
December	2,761,251	131,964	3,933,093
Totals	34,004,293	2,197,903	52,736,351
Daily average	92,908	6,005	144,088
1929			
January	2,778,228	135,147	3,978,330
February	2,550,975	137,824	3,774,851
March	2,900,617	179,528	4,469,692
April	2,780,486	203,496	4,530,553
May	2,955,682	265,517	5,201,954
June	3,072,553	301,482	5,560,273
July	2,997,155	261,393	5,117,053
August	2,869,209	215,296	4,584,417
September	2,905,133	193,284	4,499,726
October	2,911,223	153,858	4,255,945
November	2,799,965	142,672	4,036,929
December	2,781,546	139,515	4,030,207
Totals	34,302,772	2,329,012	54,039,930
Daily average	93,980	6,381	148,055

* Ratio of cream to milk 1 to 10. Ratio of condensed to milk 1 to 3.

BY-LAWS OF A PRODUCERS' DAIRY COMPANY

ARTICLE I

NAME

The name of this corporation shall be The Producer's Dairy Company of ———.

ARTICLE II

PURPOSES

The nature of the business to be transacted and the purposes to be promoted and carried out by this corporation are as follows:

(*a*) To buy, sell and generally deal in and with milk; to pasteurize, condense, preserve and evaporate milk and manufacture butter, cheese, ice-cream and other dairy products; to buy, sell and handle fresh milk, and all kinds of garden, farm and dairy products; and to deal generally in and with food products and farm supplies of every kind and description.

(*b*) To lease, build, purchase or otherwise acquire storehouses, packing houses and factories for handling and storing milk, butter, cheese or other food, farm and dairy products, and to sell or otherwise dispose of the product and such storehouses, packing houses and factories.

(*c*) To conduct and carry on any other business, manufacturing or otherwise, which may seem advantageous or useful in connection with the general business of the company, to manufacture, market or prepare for marketing any goods or commodities which the company may use in connection with its business.

(*d*) To protect products of the company by trade mark, trade names, or any distinguishing name or title.

ARTICLE III

MEMBERSHIP

The membership of this corporation shall consist of producers of milk who have subscribed for at least one share of stock in this corporation and who have been approved as eligible candidates for membership by a majority vote of the Board of Managers.

ARTICLE IV

THE BOARD OF MANAGERS

Sec. 1. The Board of Managers of this corporation shall consist of the President, Vice-President, Secretary, Treasurer, and three Directors.

Sec. 2. The members of the Board of Managers shall hold office for one year or until their successors are elected and have qualified.

Sec. 3. Vacancies in said Board shall be filled by the remaining members of the Board of Managers of this corporation for the unexpired term.

ARTICLE V

MEETINGS OF STOCKHOLDERS

Sec. 1. The annual meeting of the stockholders of this corporation shall be held in the City of . . . . . at a place designated by the Board of Managers on the first . . . . . in . . . . . at . . . . . .

Sec. 2. At the annual meeting, reports in writing shall be presented by the Board of Managers, the president, and the treasurer, together with the report of the auditor. A president, vice-president, secretary, treasurer and three directors shall be elected for the ensuing year, and such other business may be transacted as may properly come before the meeting.

Sec. 3. Special meetings may be called by the president, and shall be called by him within ten days of the receipt of a written request for such meetings signed by ten or more stockholders. Notice of such meetings shall be sent to each stockholder five days in advance of the date of the meeting and shall state the purpose for which such meeting is called.

Sec. 4. At all meetings each stockholder shall have one vote and only one, and voting by proxy shall not be permitted.

Sec. 5. At all meetings twenty-five members shall constitute a quorum for the transaction of business.

ARTICLE VI

DUTIES OF OFFICERS AND BOARD OF MANAGERS

Sec. 1. The president shall preside at all meetings of the corporation and Board of Managers; he shall call all meetings except as otherwise provided, and perform all other duties appertaining to his office and any assigned him by the corporation or Board of Managers.

Sec. 2. It shall be the duty of the vice-president to perform the duties of the president in his absence and when for any reason the office of president may become vacant.

Sec. 3. The secretary shall keep a record of all meetings of the corporation and Board of Managers, and shall keep the corporate seal of the corporation; he shall be custodian of all books, papers and other valuable instruments belonging thereto, and shall be keeper of all things necessary to the transaction of the general business of the corporation.

Sec. 4. The treasurer shall receive, deposit, and disburse all funds due or paid to the corporation as the Board of Managers may direct. He shall make a full and detailed report of the financial condition of the corporation at the annual meeting each year, and at such other times as called for by the corporation or the Board of Managers. He shall give sufficient bond, to be approved by the Board of Managers, for the faithful performance of his duties and for the surety of the books, papers and instruments of the corporation which may be placed in his custody.

Sec. 5. The Board of Managers shall have and exercise general control and supervision of the affairs of the corporation and perform all duties assigned to them by the articles of incorporation and by-laws. The Board of Managers may by a majority vote discharge the manager and any other officer or employee of the corporation, determine the duties of the officers and manager and fix their compensation, except as limited by the stockholders and as otherwise provided by the articles of incorporation and the by-laws of this corporation.

They shall hold regular meetings and conduct the business of the corporation on .....
Special meetings of the Board of Managers shall be held on the call of the president, or within seven days of the receipt of a written petition of three members of the Board. The president shall give the members of the Board a reasonable notice of such meetings. A majority of the Board shall constitute a quorum for the transaction of business.

They shall cause an audit and statement of condition of the business of the corporation to be made annually by a certified public accountant. The report of this audit shall be read at the annual meeting.

Sec. 6. The presiding officer at a regular or special meeting of the directors or stockholders shall not have a vote except in the case of a tie.

ARTICLE VII

THE MANAGER

Sec. 1. The Board of Managers shall elect a manager who shall have full charge of the business of the corporation under the supervision of the Board of Managers. The Board of Managers shall prescribe the various duties and may require bond in such amount as they may deem for the best interest of the association. They shall also fix his compensation.

ARTICLE VIII

CAPITAL STOCK

Sec. 1. The capital stock of this corporation shall be $100,000, divided into 2000 shares of the par value of $50 each.

Sec. 2. It is understood and agreed by both parties to this contract that milk may be obtained by the dealer from the producer in a manner similar to that in vogue at present, until such time as the pasteurization plant is in operation.

Sec. 3. No certificate of shares shall be issued to any person until the full amount thereof shall have been paid in cash, and no shareholder shall receive less than the par value of any share when disposing of the same to the Board of Managers.

Sec. 4. No person shall be allowed to become a shareholder in this corporation except by the consent of the Board of Managers.

Sec. 5. No member of this corporation shall be permitted to hold or claim any interest in this corporation exceeding the sum of $1000.

Sec. 6. No transfer of stock to any person not eligible to membership shall be valid.

ARTICLE IX

RIGHTS AND DUTIES OF MEMBER

In case any stockholder violates his contract with corporation, he shall become liable upon a majority vote of Board of Managers, to forfeit his stock or any part thereof in this corporation.

ARTICLE X

AMENDMENTS

These by-laws may be altered or amended by a two-thirds vote of the members present at any regular meeting or any special meeting called for that purpose, provided that the amendments shall have been presented in writing at a previous regular or special meeting of the corporation, or shall have been presented in writing to the Board of Managers and approved by them at a regular or special meeting of said Board.

Member Associations of the National Cooperative Milk Producers' Federation, 1928 [1]

Association	Date of Organization	Estimated Number of Members	Estimated Annual Sales
	Year	*Number*	*Dollars*
Berrien County Milk Producers' Association, Benton Harbor, Mich.	1918	168	441,000
California Milk Producers Association, Los Angeles, Calif.	1915	480	6,210,484
Challenge Cream and Butter Association, Los Angeles, Calif.	1911	15,000	15,689,910
Chicago Equity Union Exchange, Chicago, Ill.	1917	5,000	2,985,401
Connecticut Milk Producer's Association, Hartford, Conn.	1917	3,547	12,000,000
Cooperative Pure Milk Association of Cincinnati, Cincinnati, Ohio.	1915	3,400	2,022,583
Dairymen's Cooperative Sales Co., Pittsburgh, Pa.	1918	19,104	12,373,849
Coos Bay Mutual Creamery Co., Marshfield, Ore.	1919	455	449,255
Dairymen's League Cooperative Association (Inc.), New York, N. Y.	1921	43,067	85,648,162
Des Moines Cooperative Dairy Marketing Association, Des Moines, Iowa	1917	1,250	81,000
Farmer's Milk Producers' Association, Richmond, Va.	1916	106	1,200,000
Gray's Harbor Dairymen's Association, Satsop, Wash.	1918	300	330,937
Illinois Milk Producers' Association, Peoria, Ill.	1926	1,245	788,186
Indiana Dairy Marketing Association, Muncie, Ind.	1922	546	396,000
Inland Empire By-Products Co., Spokane, Wash.	1918	874	628,000
Inter-State Milk Producers' Association, Philadelphia, Pa.	1917	21,829	28,290,888
Iowa Cooperative Creameries Secretaries and Managers' Association, Waterloo, Iowa	.....	15,000	9,000,000
Land O'Lakes Creameries (Inc.), Minneapolis, Minn.	1921	73,000	47,834,068
Lewis-Pacific Dairymen's Association, Chehalis, Wash.	1919	1,000	993,695
Maryland and Virginia Milk Producers' Association, Washington, D. C.	1916	1,000	4,677,662
Maryland State Dairymen's Association, Baltimore, Md.	1917	3,700	8,161,257
Miami Valley Cooperative Milk Producers' Association, Dayton, Ohio	1922	4,000	1,318,663
Michigan Milk Producers' Association, Detroit, Mich.	1916	10,000	15,000,000
Milk Producers' Association of San Diego County, San Diego, Calif.	1917	55	548,712
Milk Producers' Association of Summit County, and Vicinity, Akron, Ohio	1917	2,300	2,701,000
Milwaukee Cooperative Milk Producers, Milwaukee, Wis.	1916	1,800	5,400,000
National Cheese Producers' Federation, Plymouth, Wis.	1914	7,500	9,033,359
New England Milk Producers' Association, Boston, Mass.	1917	20,154	30,000,000
Northwestern Cooperative Sales Co., Wauseon, Ohio	1920	4,000	979,466
Ohio Farmers' Cooperative Milk Association, Cleveland, Ohio	1919	3,500	5,841,000
Pure Milk Association, Chicago, Ill.	1925	3,500	5,477,000
Scioto Valley Cooperative Milk Producers' Association, Columbus, Ohio	1923	3,250	1,978,100
Seattle Milk Shippers' Association, Seattle, Wash.	1921	450	2,209,978
Skagit County Dairymens' Association, Burlington, Wash.	1916	1,500	2,532,123
Snohomish County Dairymen's Association, Everett, Wash.	1917	1,182	1,559,231
St. Louis Pure Milk Producers' Cooperative Association, East St. Louis, Ill.	1913	8,000*	9,600,000*
Stark County Milk Producers' Association, Canton, Ohio	1910	700	982,500
Tillamook County Creamery Association, Tillamook, Ore.	1909	700	1,851,529
Twin City Milk Producers' Association, St. Paul, Minn.	1916	7,527	9,854,354
Twin Ports Cooperative Association, Superior, Wis.	1916	316	506,000
Valley of Virginia Cooperative Milk Producers, Harrisonburg, Va.	1922	700	247,000
Whatcom County Dairymen's Association, Bellingham, Wash.	1919	1,650	2,728,951
Yakima Dairymen's Association, Yakima, Wash.	1921	909	630,000

[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri., Tech. Bul. 179, 1930.

WEIGHTED AVERAGE MILK PRICES IN DOLLARS PER 100 POUNDS, F.O.B., CITY MARKET, RECEIVED BY MEMBERS OF THE NEW ENGLAND MILK PRODUCERS' ASSOCIATION, 1920–1928 [1]

Month	1920	1921	1922	1923	1924	1925	1926	1927	1928
January	4.06	3.41	2.45	3.09	3.15	2.92	2.96	2.82	3.23
February	3.93	3.05	2.40	3.05	2.74	2.87	2.95	2.87	3.10
March	3.92	2.82	2.39	3.02	2.41	2.64	2.82	2.83	3.05
April	3.74	2.71	2.23	2.56	2.11	2.58	2.70	2.77	2.66
May	3.42	2.37	2.19	2.48	2.10	2.35	2.65	2.51	2.54
June	3.26	2.36	2.18	2.43	2.13	2.35	2.32	2.44	2.44
July	3.56	2.78	2.48	2.62	2.47	2.62	2.66	2.60	2.77
August	3.92	3.12	2.62	2.99	2.67	2.88	2.77	2.87	3.08
September	3.93	3.24	2.73	3.10	2.90	3.00	2.87	3.10	3.03
October	3.95	3.22	3.00	3.12	2.91	3.11	2.81	3.19	3.15
November	3.92	3.25	3.16	3.41	3.02	3.13	3.14	3.34	3.46
December	3.83	3.95	3.15	3.28	3.00	3.05	3.10	3.40	3.34
Average	3.79	3.02	2.58	2.93	2.64	2.79	2.81	2.89	2.99

[1] Metzger, Hutzel, Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.

WEIGHTED AVERAGE MILK PRICES IN DOLLARS PER 100 POUNDS, F.O.B., CITY MARKET, RECEIVED BY MEMBERS OF THE DAIRYMEN'S LEAGUE COOPERATIVE ASSOCIATION, 1920–1928 [1]

Month	1920	1921	1922	1923	1924	1925	1926	1927	1928
January	4.42	3.91	2.84	2.94	2.65	3.145	3.12	3.20	3.43
February	4.21	3.31	2.70	3.04	2.55	3.03	3.04	3.20	3.33
March	4.09	2.83	2.33	2.86	2.53	2.99	2.95	3.13	3.01
April	3.28	2.83	2.065	2.805	2.48	2.865	2.845	2.97	2.78
May	3.28	2.435	2.03	2.55	2.13	2.62	2.665	2.75	2.69
June	3.56	2.15	2.075	2.645	2.07	2.53	2.54	2.66	2.59
July	3.68	2.43	2.35	2.715	2.15	2.58	2.68	2.77	2.81
August	4.08	2.88	2.485	2.815	2.365	2.83	2.89	2.95	3.16
September	4.38	2.97	2.73	2.93	2.575	2.945	3.09	3.28	3.31
October	4.38	3.20	2.94	3.05	2.59	3.04	3.11	3.41	3.42
November	4.38	3.15	3.195	3.06	2.99	3.14	3.25	3.55	3.61
December	3.91	3.12	3.48	2.88	3.14	3.16	3.33	3.52	3.57
Average	3.97	2.93	2.60	2.86	2.52	2.91	2.96	3.12	3.14

[1] Metzger, Hutzel, Marketing of Fluid Milk, U. S. Dept. of Agri. Tech. Bul. 179, 1930.

WEIGHTED AVERAGE MILK PRICES IN DOLLARS PER 100 POUNDS, F.O.B., CITY MARKET, RECEIVED BY MEMBERS OF THE INTER-STATE MILK PRODUCERS' ASSOCIATION, 1920–1928 [1]

Month	1920	1921	1922	1923	1924	1925	1926	1927	1928
January	3.845	3.365	2.595	3.125	3.125	3.085	3.183	3.451	3.423
February	3.905	3.325	2.595	3.115	3.115	3.105	3.097	3.460	3.419
March	3.885	3.265	2.565	3.085	3.075	3.095	3.052	3.428	3.397
April	3.955	3.195	3.535	3.065	3.015	3.105	3.036	3.426	3.376
May	3.785	2.595	2.475	3.185	2.925	2.985	2.790	3.302	3.287
June	3.685	2.375	2.485	3.235	2.945	3.075	2.800	3.281	3.265
July	3.665	2.565	2.545	3.415	2.975	3.065	3.051	3.338	3.330
August	3.885	2.585	2.525	3.365	2.965	3.045	3.053	3.316	3.350
September	3.985	2.585	2.605	3.445	2.975	3.125	3.246	3.372	3.384
October	4.385	2.645	3.155	3.575	3.155	3.145	3.404	3.396	3.387
November	4.385	2.645	3.155	3.165	3.155	3.205	3.447	3.416	3.489
December	3.455	2.645	3.155	3.165	3.155	3.375	3.459	3.419	3.489
Average	3.902	2.816	2.699	3.245	3.048	3.118	3.135	3.384	3.383

[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.

WEIGHTED AVERAGE MILK PRICES IN DOLLARS PER 100 POUNDS, F.O.B., CITY MARKET, RECEIVED BY MEMBERS OF THE MARYLAND STATE DAIRYMEN'S ASSOCIATION, 1918–1927 [1]

Month	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927
January	3.05	4.13	4.27	3.45	2.52	2.97	3.00	2.99	3.03	3.32
February	3.05	3.84	4.15	3.34	2.49	2.98	3.03	3.03	3.04	3.33
March	3.05	3.16	4.00	2.84	2.46	2.95	3.00	3.00	2.98	3.27
April	3.05	3.14	3.84	2.82	2.45	2.96	3.02	3.05	2.99	3.24
May	3.05	2.99	3.67	2.73	2.27	2.92	2.85	2.93	2.85	2.97
June	3.05	3.05	3.67	2.19	2.27	2.87	2.78	2.98	2.74	3.06
July	3.05	3.05	3.71	2.53	2.30	2.96	2.92	3.05	2.99	3.18
August	3.05	3.51	3.98	2.48	2.41	3.28	2.92	3.00	3.03	3.18
September	3.98	4.21	4.21	2.40	2.45	3.61	2.87	3.14	3.06	3.22
October	4.21	4.21	4.21	2.59	2.59	3.63	2.97	3.25	3.32	3.32
November	4.44	4.21	4.09	2.59	2.82	3.28	3.10	3.27	3.39	3.33
December	4.44	4.21	3.51	2.59	3.17	3.17	3.04	3.22	3.36	
Average	3.46	3.64	3.94	2.71	2.52	3.13	2.96	3.08	3.07	3.22

[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.

WEIGHTED AVERAGE MILK PRICES IN DOLLARS PER 100 POUNDS, F.O.B., CITY MARKET, RECEIVED BY MEMBERS OF THE DAIRYMEN'S COOPERATIVE SALES CO., 1923–1928 [1]

Month	1923	1924	1925	1926	1927	1928
January	3.80	3.57	3.04	3.15	3.39	3.37
February	3.74	3.21	3.04	3.09	3.35	3.03
March	3.57	3.10	3.09	3.06	3.35	2.99
April	3.57	2.98	3.04	2.85	3.01	2.73
May	2.80	2.57	2.48	2.60	2.84	2.68
June	2.80	2.68	2.86	2.60	2.76	2.58
July	3.04	2.80	2.92	2.63	2.82	2.71
August	3.16	2.80	2.98	2.93	2.90	2.97
September	3.33	2.92	3.09	2.93	3.12	3.09
October	3.51	2.92	3.27	3.16	3.46	3.83† 2.50†
November	3.74	3.04	3.27	3.52	3.51	3.83† 3.25†
December	3.68	3.16	3.27	3.54	3.45	3.82† 3.24†
Average	3.40	2.98	3.03	3.01	3.16	

[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.
† Basic surplus price.

WEIGHTED AVERAGE MILK PRICES IN DOLLARS PER 100 POUNDS, F.O.B., CITY MARKET, RECEIVED BY MEMBERS OF THE COOPERATIVE PURE MILK ASSOCIATION, 1920–1928 [1]

Month	1920	1921	1922	1923	1924	1925	1926	1927	1928
January	4.44	3.90	2.70	2.70	3.20	2.25	2.50	.....	2.70
February	4.25	3.30	2.70	2.70	2.95	2.25	2.50	.....	2.60
March	4.20	3.30	2.30	2.70	2.60	2.45	2.40	.....	2.60
April	3.70	3.15	2.30	2.60	2.60	2.50	2.25	2.50	2.40
May	3.80	2.50	2.30	2.50	2.20	2.60	2.15	2.30	2.25
June	3.60	2.60	2.30	2.40	1.80	2.60	2.15	2.30	2.25
July	3.60	2.70	2.30	2.45	1.80	2.60	2.15	2.50	2.50
August	3.85	2.70	2.50	2.50	1.80	2.30	2.40	2.50	2.50
September	3.90	2.70	2.50	2.70	1.80	2.30	2.50	2.50	2.50
October	3.90	2.70	2.60	2.95	2.25	2.30	2.60	2.60	2.75
November	3.90	2.70	2.70	3.10	2.25	2.50	2.60	2.75	2.90
December	3.90	2.70	2.70	3.10	2.25	2.50	2.70	2.75	3.00
Average	3.92	2.91	2.49	2.70	2.29	2.43	2.41	2.52	2.58

[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.

WEIGHTED AVERAGE MILK PRICES IN DOLLARS PER 100 POUNDS, F.O.B., CITY MARKET, RECEIVED BY MEMBERS OF THE TWIN CITY MILK PRODUCERS' ASSOCIATION, 1918-1928 [1]

Month	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928
January	2.80	3.30	3.15	2.65	1.95	2.68	2.48	2.20	2.35	2.48	2.57
February	2.70	2.57	3.05	2.40	1.90	2.50	2.41	2.20	2.25	2.50	2.50
March	2.50	3.12	3.80	2.33	1.90	2.47	2.20	2.23	2.20	2.50	2.52
April	2.42	3.00	3.90	2.25	1.93	2.42	1.80	2.23	2.12	2.50	2.48
May	2.31	2.95	2.70	1.75	1.85	2.35	1.80	2.29	2.15	2.35	2.42
June	2.25	3.00	2.70	1.60	1.82	2.25	1.85	2.20	2.18	2.31	2.43
July	2.30	3.05	2.57	1.80	2.00	2.35	1.85	2.20	2.25	2.31	2.48
August	2.55	3.15	3.21	2.15	2.10	2.75	2.20	2.33	2.27	2.38	2.56
September	2.75	3.10	3.25	2.25	2.42	2.68	2.20	2.65	2.32	2.48	2.65
October	3.20	3.10	3.42	2.25	2.55	2.62	2.20	2.70	2.41	2.60	2.64
November	3.50	3.15	3.23	2.25	2.65	2.52	2.25	2.70	2.50	2.63	2.60
December	3.70	3.15	3.00	2.10	2.80	2.50	2.22	2.65	2.52	2.63	2.61
Average	2.75	3.05	3.16	2.15	2.16	2.51	2.12	2.38	2.29	2.47	2.54

[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.

RETAIL MONTHLY PRICE OF MILK IN CENTS PER QUART DELIVERED TO FAMILY TRADE IN INDICATED MARKETS, 1920–1928 [1]

Market and Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Boston:												
1920	17	17	17	17	16	16	17	17.5	18	18	18	18
1921	17	16.5	16	15.5	15	15	15	16	15.5	15	15	15
1922	13.5	13.5	13.5	13.5	12.5	12.5	13.5	13.5	13.5	14.5	14.5	14.5
1923	14.5	14.5	14.5	13.5	13.5	13.5	14	14.5	14.5	14.5	15.5	15
1924	14.5	13.5	12.5	12	12	12	12.5	13.5	14.5	14.5	14.5	14.5
1925	14.5	14.5	13.5	13.5	13.5	13	14	14.5	14.5	14.5	14.5	14.5
1926	14.5	14.5	14.5	14.5	14.5	13.5	14.5	14.5	14.5	14.5	14.5	15
1927	14	14	14	14	14	14	14	15	15.5	15.5	15.5	16.5
1928	16	15.5	15.5	14.5	14.5	14.5	14.5	12.5	15.5	15.5	15.5	15.5

Data from yearbooks of United States Department of Agriculture except for 1928.
Prices for 1928 are from Crops and Markets.
[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.

RETAIL MONTHLY PRICE OF MILK IN CENTS PER QUART DELIVERED TO FAMILY TRADE IN INDICATED MARKETS, 1920-1928—*Continued* [1]

Market and Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
New York:												
1920.....	18	16.5	16.5	15	15	15	16	17	18	18	18	17
1921.....	17	16	15	.....	.....	14	14	15	15	15	15	15
1922.....	15	15	15	.....	13	13	14	15	15	15	15	16
1923.....	16	15	15	15	14	14	14	14	15	15	16	15
1924.....	15	14	14	14	13	13	13	13	14	14	15	15
1925.....	15	15	15	15	15	14	14	15	15	15	15	15
1926.....	15	15	15	15	15	15	15	15	15	15	15	15
1927.....	15	15	15	15	15	15	15	15	16	16	16	16
1928.....	16	16	15	15	15	15	15	16	16	16	16	16
Philadelphia:												
1920.....	14	14	14	14	14	14	14	15	15	15	15	13
1921.....	13	13	13	13	11	11	11	11	11	11	11	11
1922.....	11	11	11	11	11	11	11	11	11	12	12	12
1923.....	11.5	12	12	12	13	13	13	13	13	13	12	12
1924.....	12	12	12	12	12	12	12	12	12	12	12	12
1925.....	12	12	12	12	12	12	12	12	12	12	12	12
1926.....	12	12	12	12	12	12	12	12	12	13	13	13
1927.....	13	13	13	13	13	13	13	13	13	13	13	13
1928.....	13	13	13	13	13	13	13	13	13	13	13	13
Baltimore:												
1920.....	16	16	16	16	16	16	16	16	16	16	16	15
1921.....	15	15	14	14	14	12	12	12	12	12	12	12
1922.....	12	12	12	12	12	12	12	12	12	12	12	13
1923.....	13	13	13	13	13	13	13	12	14	14	13	13
1924.....	13	13	13	13	13	13	13	13	13	13	13	12.5
1925.....	13	13	13	13	12	13	13	13	13	13	13	13
1926.....	13.5	13	13	13	13	13	13	13	13	14	14	14
1927.....	14	14	14	14	14	14	14	14	14	14	14	14
1928.....	14	14	14	14	14	14	14	14	14	14	14	14
Pittsburgh:												
1920.....	16	16	16	15	15	15	15	16	16	16	16	16
1921.....	15	15	14	14	14	14	14	.....	14	14	14	13
1922.....	13	12	12	12	12	12	12	12	.....	.....	14	14
1923.....	.....	.....	14	14	14	14	14	14	14	15	15	15
1924.....	15	14	14	14	14	14	14	14	14	14	14	14
1925.....	14	14	14	14	14	14	14	14	14	14.5	14.5	14.5
1926.....	14.5	14.5	14.5	14	13	13	13	14	14	14	14.5	15
1927.....	15	15	15	14	14	14	14	14	14	15	15	15
1928.....	15	14	14	13	13	13	13	14	14	15	15	15

Data from yearbooks of United States Department of Agriculture except for 1928.

Prices for 1928 are from Crops and Markets.

[1] Metzger, Hutzel, Cooperative Marketing of Fluid Milk, U. S. Dept. Agri. Tech. Bul. 179, 1930.

RETAIL MONTHLY PRICE OF MILK IN CENTS PER QUART DELIVERED TO FAMILY TRADE IN INDICATED MARKETS, 1920–1928—*Concluded* [1]

Market and Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cincinnati:												
1920	15	15	15	15	15	15	15	15	15	15	15	15
1921	15	14	14	14	13	13	13	13	13	13	13	13
1922	13	12	12	12	12	12	12	12	12	12	12	12
1923	12	12	12	12	12	12	.....	12	12	14	14	14
1924	14	14	14	14	14							
1925	.....	.....	.....	.....	12	.....	.....	.....	.....	12	.....	12
1926	.....	.....	12	.....	.....	12	.....	14	12	12	12	14
1927	14	14	14	14	14	14	14	14	14	14	14	14
1928	14	.....	.....	.....	14	14	14	14	14	.....	14	14
Chicago:												
1920	15	15	14	14	14	14	15	16	16	16	15	14
1921	14	14	14	14	14	14	14	14	12	12	12	12
1922	12	12	12	12	12	12	12	12	12	12	12	12
1923	12.5	13	13	13	13	13	14	14	14	14	14	14
1924	14	14	14	14	14	14	14	14	14	14	14	14
1925	14	14	14	14	14	14	14	14	14	14	14	14
1926	14	14	14	14	14	14	14	14	14	14	14	14
1927	14	14	14	14	14	14	14	14	14	14	14	14
1928	14	14	14	14	14	14	14	14	14	14	14	14
Minneapolis:												
1920	13	13	13	13	13	13	13	14	14	14	14	14
1921	13	12.5	12	12	11	10	10	11	11	11	11	10.5
1922	10	10	10	10	10	10	10	10	11	11	11	11.5
1923	11	11	11	11	11	11	11	12	12	12	12	12
1924	12	12	12	10	10	10	10	11.5	11	11	11	11
1925	11	11	11	11	11	11	11	11	12	12	12	12
1926	12	11	11	11	11	11	11	11	11	11	11	11
1927	10	11	11	11	11	11	11	11	11	12	12	12
1928	12	12	12	12	12	12	12	12	12	12	12	12
Los Angeles:												
1920	16	16	16	16	16	16	18	18	18	18	18	18
1921	18	16	16	16	.....	16	15	14	14	14	14	14
1922	14.5	14	14	14	14	14	14	14	14	14	15	15
1923	15	15	15	15	15	15	15	15	15	15	15	15
1924	15	15	.....	16	15	15	17	15	17	17	14	14.5
1925	14	14.5	15	15	15	15	15	15	15	15	15	15
1926	15	15	15	15	15	15	15	15	15	15	15	15
1927	15	15	15	15	15	15	15	15	15	15	15	15
1928	15	15	15	15	15	15	.....	15	15	15	15	15

Data from yearbooks of United States Department of Agriculture except for 1928.

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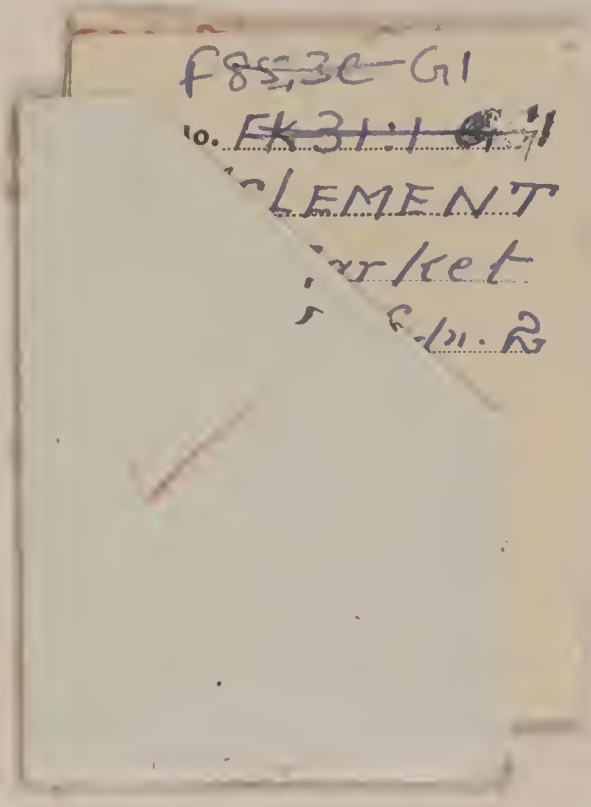
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